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Improving Energy Usage Behavior with Social Network Context

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Espoo, July 3, 2015

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ABSTRACT OF
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<p>Energy is one of the most necessary resources for people’s survival, as it is needed in every sector of the society, from food production to powering computers and machines. As energy demand tends to grow, new energy supply is a recurrent research topic, where researchers try to come up with solutions for handling the existing resources and optimizing their use.</p> <p>The use of Information and Communication Technologies (ICT) can be included in this optimization of energy use, bringing psychological concepts to the digital environment.</p> <p>In this work, we propose an ICT social platform for measuring and enhancing individual and community energy saving actions at households and workplaces. Through sharing, challenging and comparing the consumption inside a social network context the system promotes behaviour change with focus in sustainability.</p> <p>This thesis depicts the conception of an unique crowd-sourced social network, from the ideation based on social interventions to the implementation using the LEAN approach.</p> <p>EnergyUP, as the application is called, has the goal of raising awareness for the environmental impacts of energy use, changing the mindset and the behaviour of users in order to achieve efficient usage of energy. After prototyping several versions of this mobile application, we evaluated the application in user tests and confirmed potential for its success. The CIVIS project, under which this thesis is conducted, will continue future work towards full implementation and real test bed tests.</p>			
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“Si Deus pro nobis quis contra nos” - Romans 8:31

Espoo, July, 2015

Yuri Grossi Barbosa Barssi

Abbreviations and Acronyms

ICT	Information and Communication Technologies
OSN	Online Social Networks
TEDIC	Technological developments, Economical growth, Demographic factors, Institutional factors, Cultural developments [6]
IoT	Internet of Things
IHD	In Home Display
DOW	Description of Work
JS	JavaScript
TAM	Technology Acceptance Model[17]
PU	Perceived Usefulness
PEoU	Perceived Ease of Use

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Chapter 1

Introduction

The world nowadays is changing fast. The planet can not renew its natural resources as before, due to not being able to keep up with the accelerated rhythm of the population growth and imposed demand on natural resources. When there is more people, there is more demand for resources, and one of those resources in need is energy.

Energy is one of the most necessary resources for people's survival. It is needed in every sector of the society, to produce food, to light streets providing security and to turn on computers and machines. Nevertheless, it is known that more and more energy will be necessary, as every equipment gets a smart version nowadays and the electronic appliances at households tend to become more complex and grow in absolute number.

Currently, several groups of scientists spend their time and put efforts on creating new techniques to produce energy, where clean energy is a big concern. However, some clean energy sources depend on the planet's capacity of renewing its resources. For instance, places that depends on hydroelectric dams depends also on the rain cycles and river flows.

Also, part of the clean energy sources are intermittent, as solar panels can produce a lot of energy during some time, and very little at others. Likewise, the difference in the production from one year to another can be huge comparing the same period, posing a big challenge for prediction of production in advance.

As energy demand tends to grow, and new energy supply is a recurrent research topic, we try to come up with the necessary approach of handling the resources we have in hands and optimizing their use. Households represent an important part of the total energy consumption. Yet, up to 30% of the energy used in households is considered waste [21], not mentioning still the huge amount of energy wasted just after production and which do not even reach the customers.

Information and Communication Technologies (ICT, from now on) has one of the most important roles on today's society and in different fields. The correct use of its power can shorten distances, provide analysis, reveal problems and spread information, leading to a daily revolution in the information era.

The ICT solutions can also bring abstract psychological concepts to the on-line environment. For instance, the use of On-line Social Networks (from now, OSN or just SN) to represent social relations and friendships virtually, may afterwards be used for different matters, such as helping, understanding and improving people's behavior or finding people with same interests.

1.1 Motivation

Since long time ago, the increasing use of energy has been an issue, and producing more power was the most frequent applied solution. The huge growth on coal mining helped pump up the Industrial Revolution, and the world would look different today if it did not happen.

However, it is interesting to notice that the production of energy does not cause a reduction in demand afterwards. Human kind finds ways to use more energy to support and not waste the production, even if we create ways of wasting it to fill commercial purposes. The biggest issue happens when the demand finally gets bigger than the offer.

The current energy situation in Brazil can be clearly used as study case. Brazil is one of the countries with the cleanest energy matrix around the globe, where the provision of energy coming from clean resources reaches 85%, and two thirds of the total amount of produced energy comes from hydro power, according to the Brazilian National Agency of Electrical Energy (ANEEL) [1]. The energy used to light households and buildings comes from hydroelectric plants in average in 75% of the cases.

In order to produce the amount of energy necessary to supply more than 200 million inhabitants, Brazil needs its dams and water reservoirs full, directly depending on the rain cycle. Unfortunately, the country has been suffering from severe drought in the past years.

In order to keep this work focused on the energy, we will not even mention the other problems generated by this draught, such as lack of water for drink, home usage, agriculture etc.

In January 2015, a series of blackouts in eleven states affected directly and indirectly almost half of the country's population due to diverse problems, such as lack of the production in comparison to the energy demand, a hot summer (leading to an increase on the use of air conditioners and fans) and

energy misuse and waste (i.e., old equipments, irresponsible use, etc.).

With the water reserves bellow the dead volume, measurements were taken to avoid deep crisis in the energy sector. The first reaction was to buy energy from neighbours, such as Argentina, which historically were consumers and became providers of energy during this difficult time.

When seen that this action does not solve the problem, there was an increase on the production of energy using fossil energy power plants, such as gas and oil. The price to start, maintain and produce energy of this kind are way more expensive, and the final cost is redirected entirely to the final users.

To avoid rationing, the government created two different adjustments on the price. The value of energy can be increased each month, and varies depending on the necessity of producing energy using the thermoelectric plants. In the most populated region of the country, the average increase is about 40%, still not mentioning the normalization of prices due to inflation, which will increase even more the price of energy bills for every customer. This situation will not change until the energy crisis is resolved.

In sum, the climate change and the current insufficient renewal of the planet's resources transforms the issues on energy provision into taxes and expenses to the final user.

1.2 Problem Statement

According to the following situation, the country is creating measures to work with the current production and reduce the consumption by charging more from the users. However, promoting changes by means of increasing the energy price does not lead to acquired knowledge.

In any case, the users will have to target the biggest enemy of the resources consumption: misuse and waste of energy.

The current measures used by governments and energy providers, such as campaigns and advertisements, do not provide the necessary involvement and awareness to create long term changes. There should be better ways to create more efficient approaches to target correctly the users and their actions in order to change their mindset.

The mindset of the people has to be changed, as the current approaches are not enough to sustain the actual consumption, and as the renewable energy sources are intermittent, and depend on the planet.

To achieve more efficient use of energy, every user has to look at their own actions in order to change the current situation. This means that the users have to start paying attention to their consumption and their energy

meter at their households.

However, how to change people's minds, if they do not know what to do, how to do, and mainly 'if' they need to change their behavior? This is the problem we aim to target in this work.

1.3 Research Questions

In this thesis, we analyse the current approaches and studies regarding energy consumption in households, the methods used to understand the user behavior and the techniques to enhance and reduce the use of energy. Also, we propose the use of mobile ICT to create a tool which brings the necessary involvement to the users. Nevertheless, we analyse the gains provided by social network context, in order to bring community awareness and promote social engagement which can create implicit impact on users.

The objective of this work is to understand the power of ICT and OSN's to develop efficient energy consumption as well as to improve the behavior of users in households.

In this work, the following research questions will be discussed:

- How we can improve the behavior of users and make their everyday consumption more efficient?
- What special gains ICT and the current mobile technologies can provide?
- How interactions or inter-dependencies between individuals increase or decrease their engagement on the practice of reducing energy consumption (and in particular, in the case of interactions based on challenges)?

1.4 Proposed Solution Model

To answer the above mentioned research questions, we propose the conception and development of a mobile social platform, which focus in promote savings strategies in the form of tips and actions to the energy users. Therefore, we will use ICT as a link to connect the energy and the social networks together.

The goal is to provide ways to measure and enhance individual and community energy consumption behavior at households and workplaces, through sharing, challenging and comparing the consumption results inside a social network context, where the developed features are grounded on social interventions based on behavioral psychology.

1.5 Helpful Hints

In the present thesis, we use frequently the word energy. In all the cases, its use refers to energy as electrical energy power. In order to reference publications and articles, we use numbers inside brackets as reference. When is necessary to quote an author, in order to use their own words, double quote marks with text in *italic* is used. For presenting the point of view of an author, we mention the author(s)' name, and the bibliography number referring to the work.

1.6 Structure of the Thesis

The thesis is structured as follows. Chapter 2 describes the background and theory regarding the three networks (energy, Mobile ICT, Social Network Context) which give base to this work as well as practical solutions and similar applications that target energy efficiency. Chapter 3 describes the related work, in a literature review about energy saving strategies, focusing on social based interventions. In Chapter 4, we depict the concept of the proposed solution, discussing about the functional part of the system as well as the use of the application. Furthermore, in Chapter 5, we talk about the methodology and user studies, reviewing the process of prototyping and iterating on versions until the conception of a working application, and the results of the user tests we conducted. Last, we propose a discussion about the topic in Chapter 6 and finish with conclusion in Chapter 7. The appendix has details and discussion about the prototypes created, and also graphics, diagrams and tables providing further details of the user tests.

Chapter 2

Background

Chapter 2 introduces a study of the background on the proposed fields. It describes the studies and approaches to understand energy consumption analysis, and a theory base for the ICT and social network. Also, we discuss the existing solutions and describe how they work, as well as the similarities with the proposed solution.

2.1 About CIVIS

CIVIS [2] is a research project from the European Union with the objective of researching and promoting reduction on energy use and curtailment on carbon emissions. Focusing in exploring the power of ICT, communities and social networks, this project aims to achieve a more sustainable and energy optimized smart city.

With ten European universities¹ as partners, CIVIS split the research work in different sets of activities, the so-called work packages, and defined research groups composed by its partners, with objective of handling these research tasks. The focus is to allow groups to perform tests and evaluation of the available technologies, elucidate and develop models and appraise their capacity of achieving the initial goals of the project, as well as foresee the impact of the deployment of the project outcome on European scale.

The project builds on three networks, which are social, ICT and energy. It is possible to see, in figure 2.1, the interconnection between these three

¹1. Associazione Trento RISE, Italy 2. Aalto University, Finland 3. Imperial College London, UK 4. ENEL Foundation, Italy 5. Instituto Superior Tecnico, Portugal 6. Karlsruhe Institute of Technology, Germany 7. Kungliga Tekniska Hogskolan, Sweden 8. SANTER REPLY SpA, Italy 9. Nederlandse Organisatie voor toegepast Natuurwetenschappelijk onderzoek, the Netherlands 10. Delft University of Technology, the Netherlands

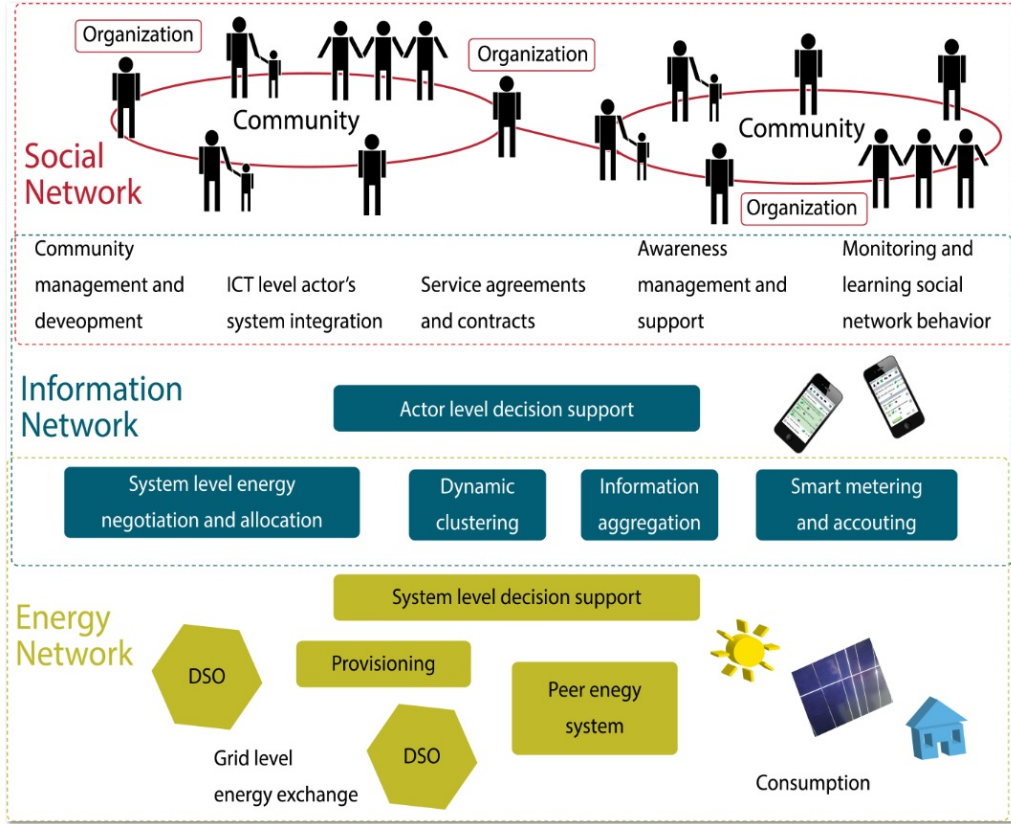


Figure 2.1: Three Networks researched by CIVIS and their interconnectivities

networks, linked together by information technology.

The results of the project will be applied to two pilot locations (Trento and Stockholm), in collaboration with research teams, energy companies, local administrators and citizen groups.

Among the outcomes of the project, there is the need of researching and developing prototypes and tests of the desired features related to the given work packages and focus group. For instance, displaying the energy consumption, creating comparison to similar households, providing tips for efficient energy use and challenges to promote saving of energy are among the depicted use cases.

2.2 Theory

In this section, we present individual analysis of the theoretical part of each component of a conceptual social energy application before creating a holistic

analysis of our work. We depict how the energy consumption should be quantified, analysed, and charged from the end user, using ICT as a means to provide the correct concept of socialization.

As explained before, CIVIS has the support of Aalto University on CIVIS WorkPackage3, with title “Enabling SMART Social participation”. The objective is to design and develop an ICT Technology which enables participation of users in an energy network. The main objectives are related to design and to manage communities, as well as their discovery, creation and to define memberships to the communities. Also, to research and design the conception and development of ICT support for specific energy services, such as consumption/use, billing/accounting, etc.

In this work, we propose the use of social interventions embedded in a crowd-sourced energy network to promote energy savings. According to literature research, using different strategies merged together can be beneficial towards savings. Darby(2001) [14] stated in her review of feedback effectiveness, that the highest results were obtained out of a mix of strategies. In the same work, Darby concluded that in fact *any* intervention helps reducing energy spending if it pushes the household owner to review their consumption. The intention should be to push the savings more, and also create means to change user behavior after all. The power of mixing different strategies to save energy has proven to be effective, as shown in section 3.1.4.

2.2.1 Energy Efficiency in Households

The main topic of this thesis is related to energy consumption in households and the current methods to reduce the energy spent in such places.

According to the U.S. Energy Information Administration, households were responsible in 2011 for 22% of the energy consumption in USA, and this number reaches 26% in Europe (numbers from European Environmental Agency). The number of households is still growing due to the population growth, and the production of energy has to cope with this increasing number.

The energy spent in households in general also keeps growing. In his work, Abrahamse et al.(2005) [6] define macro-level factors that led to this increase as TEDIC factors: technological developments, such as new energy-intensive devices; economical growth, supported by increase of household incomes; demographic factors, such as the above mentioned population growth; institutional factors, as governmental policies; and cultural developments, as emancipation and the crescent number of women mobility.

Energy use is one of the biggest villains for carbon emissions. According to Delmas et al. (2013) [19], 40% of the green house gases around the world

are accounted for energy use.

Likewise, another big issue regarding energy consumption is the amount of waste. According to Ehrhardt-Martinez et al.(2010) [21], households use up to 30% more energy than necessary. This rises the need to reduce the energy consumption, making it more efficient.

Understanding that the world's population will grow in the near future, the production of energy has to be increased proportionally to the demand. However, using properly the current resources will provide more time to clean-tech researchers to develop new efficient ways of producing energy.

Geelen et al. [25] refers to efficient energy use as *“the amount of effort expended by users in a household to reduce energy consumption and the extent to which energy efficient appliances are utilized”*.

It is clear that, to reduce energy consumption and to enhance appropriate saving behaviors, it is necessary that the user makes effort to observe their own actions and become aware of how much energy is spent in their household on a normal basis.

This lack of awareness is common and a big villain of efficiency. Users normally do not have constant access to their energy consumption information [15], mostly getting the information about their energy use through the energy bill. This could change with the adoption of smart meters in households.

Smart meters can provide more reliability in information provision and reduce the cost of feedback [19]. Furthermore, they can provide to the users the necessary clarity, turning the monitoring process more dynamic and controllable [23].

For example, smart meters have a big penetration in Finland. Due to that, it is possible to access energy information, record the consumption of the users and make it visible through different means, for instance, on the web or a mobile application, creating interesting conditions to test an energy efficiency application. According to the SmartRegions Project², Finland is one of the most advanced country in Europe for smart meter penetration, with a clear adoption strategy and legal framework, being considered as a Dynamic Mover, as it is possible to see in figure 2.2.

Despite of the increasing number of energy-efficient appliances, the efficiency of energy use mostly depends on user actions at his home, as inefficient acts may mask the real efficiency of equipments and green bulbs.

²www.smartregions.net

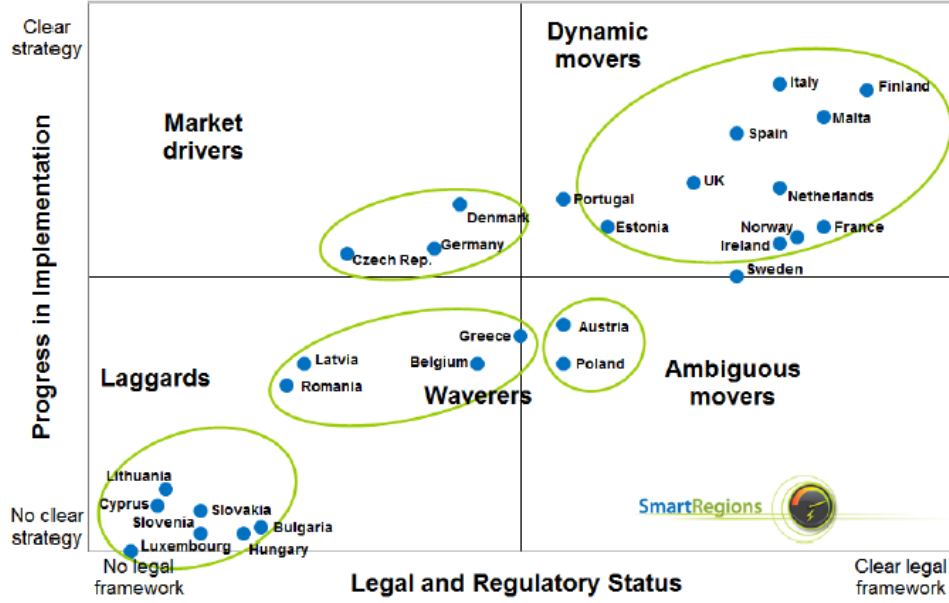


Figure 2.2: European Smart Metering Landscape (SmartRegions project, 2014)

2.2.1.1 Important Energy Factors

When talking about energy, not only the direct and indirect feedback are essential to create an application which tackles energy issues towards behavior change. There are other factors that should be taken into account, as they affect the consumption of a household, but normally remaining unnoticed to the eyes of the energy user.

Therefore, we want to avoid that the data from the current consumption could be masked in this equation. The variation of energy price, the energy peak times as well as effects that may increase the energy consumption must be analysed so the effects of the interventions can achieve reduction on the consumption.

For instance, providing ways for load balancing reduces the possibility of failure on the proportion between demand and provision, decreasing the chances of unexpected blackouts [38].

Following, we present some interesting factors that fit in this role. If those factors are controlled, we could deliver a better application to the user.

2.2.1.2 Energy Price Variation and Negative Prices

The constant fluctuation in energy prices depends on the relation between production versus consumption, and a matching failure in this relation causes blackouts or brownout (line voltage fluctuation).

Hot summers, which increase the usage of air conditioning, as well as the overuse of heating systems in a cold winter, can change drastically the energy demand. Households are major contributors to peak demands, especially in summer [38].

In some places, depending on the energy market rules, an interesting phenomena can occur in this field. It is known that the production of green energy depends on climate factors, such as rainfall, solar and wind activity. As described in section 1.1, the lack of rain can lead countries that drastically depend on this natural resource for electric power production to increase the energy price, and one of the reasons is that they have to use alternative fossil burning facilities to produce energy, which are more costly to operate and inflates the final price of electricity. On the other hand, during days where the energy production can be increased due to climate factors, the excess of energy produced on a day of low energy consumption can lead to negative prices [33].

Germany is the European leader in eolic energy production, with 39.2 GW of installed capacity, according to the European Wind Energy Association (EWEA) [3].

According to Nicolosi(2010) [39] the energy demand which is not covered by the wind power production (i.e. residual load) is supplied by coal burning and thermoelectric electric facilities. The oversupply of wind energy can lead the price of the energy to drop bellow zero, as it is more costly to shut down conventional energy producing facilities than to pay users to consume energy. From 2008 to 2009, it was recorded by the European Energy Exchange the amount of 86 hours of energy prices bellow negative, with 19 hours of prices under the overwhelming amount of -100 euros/MWh. This is called merit-order effect [39].

Markets with flexibility on energy production need to adapt their demand as well as their offer to the variations of the production and consumption reality, in order to avoid oversupply issues. Still, few energy markets are as economically strong as the German market to operate well with negative prices. Nevertheless, it is clear that there can be improvements on this model.

An interesting application would be one that not only helps the users balance the energy load, but also helps the entire market to understand the proportion between consumption and production in real time, in order to achieve an efficient allocation of energy production resources.

Load balancing is crucial to regulate the demand of energy on both sides, as reducing the on-peak energy consumption generate effects on the energy price, as well as reducing the risks of running out of energy on households.

2.2.2 Mobile ICT

In the past years, mobile ICT has become accessible to different social classes, and this market reaches a large number of people around the globe. According to the International Data Corporation³ [4] forecast, the global smart phone market will grow 11.9% in comparison to 2014, reaching in 2015 a total of 1.5 billion units shipped.

In 2014, the number of smart phones increased 24% [28], and nowadays 80% of cellphones sold in US are smart phones [34]. Advanced technologies support fast Internet connections, integration with GPS and appliances at home, as long as those devices have Internet connection by WIFI or blue-tooth.

The penetration of smart phones in worldwide market is expected to keep growing, and currently many appliances are being produced with possibility to connect to others, creating an internal network at home (i.e. Internet of Things). The possibility of connecting to a smart phone can add many valuable features to those appliances. And in the case of this thesis, we will focus on the connection of the mobile device with the smart meter at households and with neighbours on a social network (see section 2.2.3).

The smart phones nowadays can perform the role of In-Home Display (IHD), element necessary to an efficient direct feedback [14],[23]. This creates the possibility of, on the palm of the hand, receiving, accessing and controlling the energy consumption. Intuitive, interactive and computerized tools have the best effect to improve behavior and inform the users, according to Fischer (2008) [24].

Providing metering display is necessary, and should be applied individually to households [14], in an accessible, easy and clear way [24]. Immediacy and easy access to feedback data were shown to be highly important, as it gives the user control of his consumption [14].

2.2.3 Social Networks

Since the early 2000's, social media has become responsible for a large portion of total traffic on-line, becoming the 4th most popular on-line activity to users, pulling ahead of email according to [10]. According to Mislove et

³<http://www.idc.com>

al. [37], social networks provide a potent tool for creating, organizing, finding and sharing content and contacts, creating a small-world with scale-free properties, organized around the users, and not around content, as the Web. The use of social networks can provide several benefits to push efficient behavior in energy saving [13], enforcing that individual behavior can be carved by the use of everyday practices and community norms [35].

In the case of this work, a community related to energy matters should operate as a vehicle that promotes and provides a means for civic function, pushing people to join not only for social interaction, but to be actively involved in sustainable cause [30]. Therefore, the focus should be in creating a way users change their behavior into environmentally conscious in the end. One of the main factors why users carry environmental actions is correlated to an appropriate lifestyle towards the cause [35].

Instead of only giving the users tasks or information about what to do, it is interesting to influence user's behavior by creating "social proof" that that action is being taken by others. That is, in simple words, show people what others are doing. This technique has proven to be rather effective [43]. Hoffman(2005) [30] stated that the most difficult, neglected, yet crucial questions of energy saving strategies are not related to economical or technical issues, but rather ethical and social factors. In other words, the biggest problem is to regulate methods and strategies that can engage citizens efficiently into the energy saving cause and propagate correctly the information about the reality of each energy choice.

The intention is to provide to the users what Hoffman(2005) said are *selective benefits*, which are gains that a user can get only if he participates in a given activity, and promote *civic gratification*, which is related to feeling a sense of fulfilling a desire to make contribution to the community's welfare and doing his duty for a better society [30].

It would be interesting to create user retention using the power of social network itself. Social networks develop integration and maintenance of relationships between users, provide mechanisms to reply questions and find similar interests shared by other users, check how other users are doing, and also to locate content as well as knowledge that has been supplied or endorsed by others [37], and can be a particularly useful tool to individuals with certain difficulty to create and maintain social bonds [22].

The use of social network also opens the possibility of using relationship ties to influence people. Strong ties, related to solid relations, and weak ties, can be used in different ways to promote social influence on users.

Also, this specific type of network can benefit from latent ties, which are the ties on social networks which are not activated socially (yet are technically possible to be developed) [22]. This means that, on the proposed energy

network, not only strong ties can be used to enforce saving behavior, but get information and knowledge from a weaker ties, for example, some neighbour you see in the stairs, but you do not necessarily know the name.

In a study of structural properties of social networks, Mislove et al. [37] found that OSN's are composed by highly connected clusters composed by low-degree nodes connected together by a small number of high-degree nodes, containing a large, densely-connected core. This means that the content which is spread between groups uses a relatively short path, yet passing through the core, composed by high-degree individuals, or the so-called super-nodes. This concept creates a model of trust as well, as a node will be trusted depending on his degree of connections, and can help defining roles of block leaders or modeling roles in the proposed network solution.

One of the important elements which is necessary to enforce in the proposed energy social application is that when the on-line and offline social networks overlaps (i.e. representation of real communities on the virtual environment), this application could create a bidirectional phenomenon. In normal conditions of social networks, a known contact in real life could be represented by a tie between users in the virtual network after adding someone to the list of connections.

However, this bi-directionality represents an interesting gain for real communities. This means, the online connections formed in the application should result in face-to-face meetings, showing an *online to offline* direction, as mentioned by Ellison et al.(2007) [22]. The gain should be to create means to strengthen the relationship ties, taking advantage to use well latent ties.

2.2.3.1 Gamification Techniques

One of the known techniques that creates user retention and lock-in of the form of engagement is the concept of *gamification*, which is the use of elements from video games in non-gaming systems, achieving also improvements on the user experience [20].

Particularly, “pointification” is a subset of gamification strategies, which consists in encouraging competition and engagement using game rewards mechanisms such as points, rankings and badges [35], and increases the performance of users in games, acting as a motivator factor. However, according to his work, the insertion of community norms in the form of simple information in the application is as important as to “gamefy” it, motivating the desired behavior. This is the reason we intend to have different strategies related to social interventions to reach users.

For instance, providing data about the ranking of other participants may

encourage users to try to catch up with that model. This can happen even if they can not compete directly the performance of these user, well ranked in comparison to others [35]. This feeling creates an implicit feeling of competition, motivating the user to desire being in that place.

The social part is necessarily a crucial feature to the type of application we propose in this work, detailed in section 4. The use of social networks, with the application of saving strategies and gamification techniques, mainly pointification, can have good results to motivate users, therefore, should be considered to an application that promotes change on the everyday actions, as it would require users to use it as much as possible to increase the chances to improve their consumption behavior.

We plan to deliver tasks and challenges to the user in the form of a social context. In this case, a gamification strategy can be applied, with a reward system related to the actions taken by the user. Comparisons can be made on the form of a ranking, for example, depending on the consumption, challenges completed, and other forms that can help the user to interact with the application.

2.3 Similar Applications to Our Solution

Tackling the problems on energy consumption to make it more efficient is also not news to the users. During the past years, different applications were released based on market needs and research on energy efficiency. Many of those connects the smart meter, displaying to the customer their consumption on a fine-granular level and in novel ways.

During the time of writing this thesis, we were not aware of any solutions that unite the full power of social networks and social influence approaches as our solution does.

The intention of this section is to list some applications which have similarities with the solution proposed in this work. Due to the short time, it was not possible to compare the similar functions we have to the following presented applications, leaving space for future work (see section 6.2).

Following, we list and briefly discuss their purpose.

*OPower*⁴ uses comparative social feedback between neighbours from similar households to prompt energy savings. This company started in 2007 by the name Positive Energy, and have grown significantly in the past years. They deliver statistics of energy use on regular post, in form of reports to the users. OPower focuses on the utilities, promoting them as trusted advisers.

⁴<http://www.opower.com>

OPower delivers personalized hints to the users by understanding them, and pushes the saving using the above mentioned social comparison on feedback, but not other social aspects.

*GreenPocket*⁵ is a German start-up, which produces solutions for smart metering. Their goal is to enable the utilities and homes to save energy. Their software solution combines house measures with external data, such as weather forecast, and provide the necessary hardware to create time schedules for turning on/off the devices, bringing the necessary automation to households. By providing the real-time, customer-oriented information to households, Green Pocket creates a complete solution using the power of ICT to connect and create the necessary automation to houses.

*Grandlund*⁶ is a company from Finland which produces software solutions for maintenance management. Their product provides a solution to achieve energy efficiency by providing hourly information using the energy meter. The reports and alerts of energy overspending are sent by email. Granlund targets mostly energy managers, supporting the decision making process with their reporting application.

MyEarth is a new energy tracking application released in April 2015 to raise awareness for the carbon emissions. MyEarth allows users to select activities that fit their needs from of a list, and accounts the reduction on carbon emissions by calculating the actions the user decides to perform. The user changes levels based on the impact of his savings. This mobile application do not use any social aspects, but a gamification model which delivers hints and tips to the user, focusing on environmental awareness. Also, it does not have a reliable way to check if the user performed or not a given action. We present MyEarth in this section due to due to the similarity with our work, mainly the pointification and tips selection aspects.

⁵<http://www.greenpocket.de>

⁶<http://www.granlund.fi/en>

Chapter 3

Related Work

In this chapter, we discuss the related work and scientific studies on the patterns, behaviors, and also the incentives and techniques to achieve reduction on energy use.

3.1 Energy Saving Strategies

During the past years, several studies tried to understand and analyse the energy consumption patterns of users by observing their consumption behavior and the strategies used by individuals as well as communities.

Not only users, but utilities can also benefit from energy savings. The reduction of distribution and transmission investments, as well as avoiding incremental non-expected capacity are part of the benefits, not to mention reduction on-peak demands and green house gases, which interests everyone.

There are several ways to separate saving strategies into categories, grouping them by their type, the way and when they are delivered. Following, we briefly discuss and present insights on different categories of energy saving strategies found in the literature, focusing on the ones which corroborate to the background of this thesis.

3.1.1 Moment Based Categories

One categorization is based on when the interventions target behavior. The interventions based on influencing the users prior to taking an energy saving action are the so-called antecedent strategy, while the strategies based on describing the outcomes of an action after the user has performed it are categorized as consequence strategies.

3.1.1.1 Antecedent Strategies

Antecedent strategies are the approaches which influence individuals prior to their saving actions [6]. For example, providing information about how effective an action can be influences users to take that action. Interventions such as commitment, delivery of information, goal setting and modelling are among antecedent strategies. We discuss in more details those interventions in following sections.

3.1.1.2 Consequence Strategies

Consequence strategies are the interventions based on the aftermath of the action taken by the user. According to Abrahamse et al. [6], the presence of consequences, negative or positive, tend to influence behavior. For instance, adding a monetary incentive to pro-environmental causes raise extra attraction to this action. Information based on feedback, in a social or personal level, are also among the consequence strategies, along with pointification and pecuniary rewards.

3.1.2 Tool Based Categories

Another possible way of categorizing energy strategies is based on the different types of tools the strategy uses to create awareness to users, such as information based, price and reward based.

3.1.2.1 Information Based Strategies

According to Delmas et al.(2013) [19], information strategies are the ones based on delivering correct information about consumption and environmental impact of their actions, encouraging saving behavior to users.

Among the information based strategies, are energy audits, saving tips, providing energy usage feedback, history of individual usage, pecuniary strategies and peer usage. As seen, information based strategies can be antecedent or consequent.

Feedback, as an information based strategy, can be provided for the user with different frequencies. More, can be provided for the user in different means. Fischer (2007) [24] stated that the most successful form of feedback is the one given in an appealing and clear way, delivered frequently for the users and during a long time. Feedback strategies can be indirect or direct.

Indirect feedback is the type of evaluation that, before reaching the energy customer, is processed and tailored (e.g. billing). It raises interest and awareness of users, and savings can be achieved with relative low cost [14].

In case of more detailed information, tailored to understand user behavior, the cost and the effectiveness of the measurement should increase.

The so called direct feedback, on the other hand, is the provision of information in real time, about consumption and costs of energy, available on demand. Direct feedback has proven to be effective, with energy savings up to 20%, with average of 7% for users not involved in prepayment programs. This number doubles, to 14% of reduction in energy consumption, when user is in prepaid programs [23]. There are different types of prepaid programs, but in general, in such programs the user buys energy credits in advance, and uses it until they are totally consumed. After all, the reduction on the use of those energy credits reflects as savings in energy.

Nevertheless, Darby (2001) [14] stated that, even if feedback is necessary to raise awareness and promote savings, it is not always a sufficient condition to achieve good results. Tailored information was also an approach used in many studies, as in McMakin et al. [36], and Abrahamse et al.(2005) [6]. In those studies, it was shown that good results can be achieved by crafting the information according to the necessities of the user, his type of household and the characteristics of energy usage. Therefore, the goal is to find what is the most relevant information to provide, instead of overloading the user with general information.

3.1.2.2 Price Incentives and Rewards

Saving energy can not only produce carbon emission reduction or energy savings, but also create financial benefits, due to the reduction on the energy bill. Even though, as in [19], the energy consumption behavior of users in households is not necessarily affected by the provision of information regarding the current price of energy.

Still the literature differs about the effectiveness of pricing and pecuniary incentives, mainly when what is taken into account is the possibility of influencing the behavior of people.

According to Bénabou and Tirole (2004) [9], the creation of extrinsic incentives (e.g. rewards) can lower the value of the reputational motive, causing doubts about the real causes the activity is actually performed. Sometimes, this can cause people to turn down the rewards, partially or entirely, according to one's moral values.

Pecuniary rewards can attract new participants, but repel ones which were already performing the same activity for free, for instance, in case of blood donations [44]. The supply can be reduced, in the end, if contributors start to get payed to take some action they would have been doing without any money incentives in the first place [9].

However, in a meta-analysis of different studies, Abrahamse et al. (2005) [6] stated that, in overall, rewards appear to influence the energy savings positively, as significant difference was noted between savings of households which received rewards during the studies and those which did not receive anything.

As said before, prepaid energy programs (combined with feedback) can produce double of savings. This takes into account that the user, which already have payed a specific amount of money for his energy, will be more motivated to reduce his expenses after spending [23].

According to Darby (2001) [14], financial incentives are used and tested since the 70's and have interesting particularities. Among them, is the fact that the impact of it did not last longer, moreover, lasted until the incentive as removed. Abrahamse et al. (2005) [6] also stated that several studies suggests that rewards have a quite short-lived effect. In order to affect behavior and have a durable effect, the incentives and rewards need to be proposed in long-term.

Experiments shows that demographic factors also influence the effectiveness of an applied strategy. Savings of energy were higher, on average, in households with lower house value than ones with higher value [7].

McMakin et al. [36] proposed a study to understand the effects of customized information and conservation campaigns in behavioral changes on a place where the users do not have to pay the energy bill, as U.S. Military installations. It shows that even in these places, where customers do not have to pay their own energy bill, people can be motivated by the desire to act correctly.

This is an interesting fact, as it was believed that users would reduce their energy consumption based on the fact that they would be interested in paying less on the energy bill in the end of the month. In this case, moral factors can influence. Also, parents with kids tend to act in an environmentally conscious manner, as they tend to become models so their kids follow their good saving habits [36], also showing they were more concerned about the future of their child.

3.1.3 Social Context

The third categorization distinguishes the energy saving strategies based on whether the strategy refers to individual (personal) or community aspect (social). Due to the focus of this work on social strategies, following, we present the types of intervention which are applied to social groups.

Efficient consumption depends on the will of user's to take actions and change their energy spending, and if those actions are maintained, we see behavioral change. In this case, social approaches can help achieving good

results, as they are based on psychological basis already present, implicitly or explicitly, in our daily actions.

Social influences are proven to be effective when it comes to encouraging change in behavior [5]. Following, we review types of social influences which have shown good result in the research.

3.1.3.1 Social Norms

According to the *Oxford Dictionary of Sociology*, norms are described as “informal understandings that govern individuals’ behavior in society” [42]. Social norms are seen as the prediction of behavior while an individual faces a particular situation.

Cialdini et al.(1991) [12] describes social norms in two different branches: descriptive and injunctive norms.

Descriptive norms (also called popular norms) are the ones that tell one how to behave in determinate situation. The motivation behind is to give an advantage to someone when certain situation happens, so one can behave in accordance to what most people think is the most effective action to be taken [12]. This strategy is very much used in marketing to push people to act according to the mass, not necessarily by convincing people the product is good, but that many people use it.

Injunctive norms (or prescriptive norms) are the ones based on the principal of moral rules, such as what should be done at determinate moment. In this case, the individual follows a rule even if no one else is doing it, but because his moral concepts defines how he is going to act [12]. In fact, we tend to position ourselves and judge our actions putting ourselves on the position of someone observing us with impartiality and fairness towards our actions.

Norms and social pressure create a link between the honor of performing a good and altruistic action and attaching shame to selfish ones [9]. We, as humans, are conditioned to feel and take social norms into account when performing our daily actions.

3.1.3.2 Block Leaders and Social Networks

Information provision can have a good effect on people, mainly when delivered effectively, as we stated in subsection 3.1.2.1. In this context, if the information is delivered by someone reliable, from the same social network, mainly when the information is conveyed by someone with strong relationship ties, this information is more likely to be accepted.

Block leaders fit in this role, helping spread information about a certain issue, and profiting from his social network to help the diffusion of information. In this way, the chances of reaching a certain group with information are increased, and the effectiveness of this model is mostly due to the social ties, as he is personally known [5].

In this context, a community leader or anyone that could take a leadership part from a group can become a block leader, as long as he is well informed about the issue. Abrahamse et al.(2013) [5] indicates that, among the saving strategies based on social approach, block leaders is particularly effective.

3.1.3.3 Public Commitment Making

Commitment making is also a good strategy, as it binds a certain behavior or opinion to an individual, due to his need of consistency between his attitudes and behavior, when asked to make a pledge [5].

According to Cialdini(2001) [11], when this commitment is made in public, this approach can be especially effective. This result is due to the social pressure created by sticking to a commitment, which may encourage change of behavior.

3.1.3.4 Modelling

Modeling is an intervention based on creating a relevant example of something to be achieved, such as a recommended behavior [6]. By taking a sustainable house, a constant saving behavior or the skills of a musician as a model, people will start engaging this behavior if they like the model (principle of *liking*) or depending on the similarity they have with the model. The base of modeling is social learning.

According to Abrahamse et al.(2013) [5], behavior is most likely to be followed and modeled if it is meaningful, easy to understand and relevant, rewarding people with a favourable outcome.

Studies show that modeling results in knowledge increase and was effective in reduction of energy use [6]. Also, when more than one models are used, the compliance with the goal of conserving resources is higher, possibly, due to the fact that a descriptive norm supporting this behavior becomes more evident when more people are engaged, encouraging behavior change.

3.1.3.5 Social Comparison (in Feedback Provision)

As described in session 3.1.2.1, feedback provision can be a profitable tool applied with other interventions. By providing a comparison between the previous behavior of a user and his actual behavior, user can understand

how well he is doing. In this part, we talk about comparison of data on a different level.

Social comparison refers to the idea of using data from different users and relating them to each other in a meaningful way, and two types of social comparison can be distinguished. The first, called *upward social comparison*, happens when people compare themselves to someone who is doing better on that matter. On the other hand, in downward social comparison, one compares their situation to someone who is doing worse, and in this case, this person would feel better with their own situation [5].

Using the feedback information, the user receives their record about their own performance, compared to the performance of other relevant people, evoking the the upward or downward comparison. There is also the tendency of creating a salience around a social norm, creating a co-relation between the norm and the recipient of feedback, without the necessity of creating direct comparison [5].

3.1.3.6 Group Feedback

When it comes to feedback, another variant described in literature is the feedback given in groups. For instance, providing information about master-measured apartments (i.e. places without their own energy meters) or the total spending of electricity by groups of people in an aggregated way can be considered as group feedback interventions. In this way, collective effort to reduce the consumption takes into account the reduction of consumption of every subject, enhancing the feeling of efficacy in a collective way.

The similarity with social norms lies on the fact that both of them deliver information about other people, concerning what and how they are doing. The difference is that the group feedback includes the recipient itself in the aggregation. It differs also from Social Comparison in the way that it does not disclose the individual contribution of the subjects [5].

3.1.4 Combined Strategies

One of the main issues found on the literature in this area is that the studies normally apply and test more than one saving strategy, leading to complications to quantify how much savings one particular strategy can generate alone [19],[14],[6]. Nevertheless, saving strategies can have better results when applied in combination [14],[6].

Meta-analysis is a technique to combine statistical evidence from different and independent studies into one analysis, in order to provide a systematic overview of what is on the literature, according to Delmas (2013) [19].

Delmas et al. [19] proposed a meta-analysis tried in order to compare the impact generated by multiple energy conservation-based strategies, such as saving tips, historical individual usage, real time information, feedback, energy audits, pecuniary measures among others.

As a result, it was found that studies using audits had the highest energy saving average, around 13,5%, succeeded by social comparisons with average of 11,5% of savings. Also, it was proven that real time feedback generates significant economy in energy spending.

Abrahamse et al.(2005) [6] reviewed 38 different intervention studies to evaluate how effective the measurements. In this study they separated the interventions into antecedent and consequence strategies, and observed if the intervention resulted in reduction on energy use and/or behavioral changes, the extent of the result that could be attributed to the interventions and other factors. Information strategies increase considerably the knowledge level of users, but this does not necessarily result in energy savings or changes in behavior. Also, he revealed that, despite of short-lived effects, rewards had an effective effect on encouraging conservation. Feedback was effective, mainly when frequently given. Combining reward in a contest with comparative feedback has proven to be successful [6]. Combining goal setting, mainly with a difficult goal, with feedback provision resulted in energy conservation and had a better result than goal setting alone [6].

In a meta-analysis of random effects of social influences using of 29 studies, Abrahamse et al.(2013) [5] showed that some social interventions were more effective in comparison to others, such as deliver prior information, provision of social feedback and community goal setting, although the effect size was relatively small. In fact, this does not mean some social influences are not good enough to be applied alone, but it was shown that a combination of both different types of social interventions can generate a good result.

3.2 Unexpected Behaviors

When it comes to saving energy, it was shown in studies and research that the interventions can generate an unexpected effect.

For instance, if the energy price is really low, or produces small contribution to household expenses, *boomerang*, *rebound* and *licensing effect* can be seen. However, studies show that the combination of injunctive and descriptive norms can neutralize those effects [12],[7].

Bellow, we list and discuss how energy saving interventions which are proven to work in a big part of the cases, can generate an increase in the energy consumption in the end.

3.2.1 Boomerang Effect

In energy efficiency, *boomerang effect* occurs when a household has the energy consumption increased after learning that their consumption is lower than their neighbours [13],[41].

Programs using peer feedback can experience this effect, related to receiving information about the usage of the community, and learning that their performance was more efficient than the others, leading to an increase on the unwanted behavior [7],[41],[12].

For instance, households which have good saving behavior according to a norm (i.e. which were already using low energy) had their energy consumption increased following feedback from social norms [5].

3.2.2 Licensing Effect

One other possibility of unexpected effect happens when users receive energy saving information, but even with the increased knowledge, the theory is not applied to practice. According to Delmas et al. [19], in some cases, users can judge the savings generated by what they learned as too small to be meaningful, leading them to ignore possible savings. The so-called *licensing effect*, happens because the user feels entitled to profit from energy use, due to the simple fact that he is paying for it.

3.2.3 Rebound Effect

The *rebound effect* (also called take-back), is caused by a reduction on the price of energy that may lead to increase on the consumption. This reduction can be led by an increase on the energy services supply, decreasing the direct price. This effect can lead to an increase on the demand of the energy due to a low price [26].

On household level, improvements on the energy efficiency may also cause the same effect due to a reduction on the final price of the energy. These improvements can be made by changing appliances or light bulbs to efficient ones. As the reduction in first place can be huge, the user tends to use more, and become relapse on his behavior, where he starts to take-back a part of the energy savings [29].

Therefore, encouraging technological innovation on appliances in order to increase efficiency in energy consumption are not enough to achieve reduction on energy use, making other interventions required [29].

Chapter 4

Conceptualization of the Solution

In this section we describe the proposed solution itself, first with an overview of how the system should work, explaining the features of the system, and the implementation strategies.

When imagining what should be the outcome of this work, we should think about what would be the gains generated by the three pillars previously mentioned in section 2.1 (and represented in figure 2.1).

The use of mobile ICT should bring the necessary scalability to this project. By reaching different markets, and connecting to different appliances using well known protocols, smart phones can finally become a well trusted, portable personal IHD, necessary to receive information from our system. The user can manage and access his consumption data, properly collected from the smart meter and analyzed on our back-end.

The information about the cost of energy, the past and current prices, as well as the variation of the value of the energy, should be smoothly delivered to the users. As discussed in section 3.1.2.2, the price of energy should not be considered a strategy to reduce energy by itself. However, if we manage to deliver well-tailored statistic, we could create another mechanism to retain user attention. Users could be searching about how to profit from a day of low energy price, or comment the variation of energy during a specific week. This possibility may enhance customer retention, which is one of the goals of any application.

On the part of social network aspect, it is crucial to create ways to deploy the saving strategies discussed in section 3.1.3, merging also with the goals set by CIVIS for this work package. The communities, feed and interactions between users are the features of the proposed application where we target the insertion of the social norms and energy saving strategies presented in chapter 3.

Part of the strategies should be inserted implicitly or explicitly in the

form of challenges, tasks, comparison, tips, etc. The user does not have to necessarily recognize the social norms behind each challenge, as long as he interacts with it and understands the real meaning of an activity. For instance, the user has to acknowledge the benefits of “unplugging stand by appliances” by using the application. In the beginning, he can perform this or other tasks to level up. The level of awareness has to increase also, and eventually the user will perform this task automatically, without the obligation to be interacting with this challenge anymore.

4.1 Proposed System

After all, we describe the parts of the system as blocks in order to separate in modules the system itself.

- User App (frontend): An application, developed to connect with the backend, and act as the user interface, providing interaction to the system. The use of mobile phone provides scalability to the system, and act as a mechanism for displaying results as the previously mentioned IHD.
- Server (backend): The Server of the application is used to handle the data from profiles, challenges and energy consumption from the user. The backend should count with algorithms for Data Analysis, and Machine Learning. Still, the server side has to be able to establish connection with the smart meter and receive the updates from current consumption of the household, if applicable.
- Smart Meter: in order to fully work in an automatized way, the proposed solution should connect to an energy meter at the user’s household, however, not being a necessary condition to allow the application to work. This could give a special power to this application, as the energy user may just need a login and take the proposed actions at his place, checking the effects on the energy bill or the conventional meter.
- Gamification: This mechanism will be used to provide customer lock-in and extend reuse of the application. The application will provide actions, challenges and tips to the user, where a pointification system will act as reward means to push user to save and enhance user experience.
- Social Network: The objective of the social network context is not only the insertion of social norms and saving strategies, but mainly

to enhance user engagement and saving incentives in order to obtain better results, achieving behavioral change.

4.2 Features and Functionalities

On the system level, there are a series of features related to the application of the correct techniques to prompt energy savings. They can be implicit to the system, i.e., the user does not interact directly with it (presented in this work as functionality), or explicit, such as a feature of the system (shown further as a system function). Bellow, we depict these system functions and functionalities, and explain how they should be applied to the system.

4.2.1 Functionalities of the System

Following, we present what kind of functionalities (i.e. internal implicit function of the system) we plan to create in the application.

- **Indirect Feedback:** By understanding how our user consumes energy, we could provide him strategies that can be more effective, and help the user save energy. For instance, if our system understands that a given user has a pattern to increase the energy consumption in morning time, we could deliver graphics and meaningful data representation to show the consumption of the user in a simple and clear way. By creating the correct comparisons (between different months, different energy prices, etc.), we want to make users more aware of the information he needs, in a way this info is always relevant and that he does not get confused by numbers alone. The main goal is to understand their behavior and tailor the information to each user, and provide actions most likely to be performed.
- **Balancing the Price of Energy:** If energy costs increase at a given time (peak hours), how can we keep a stable value using only the application. Predicting the peak hours, calculating the price and displaying to the user are crucial to deliver a good cost estimation of the energy bill, as explained in subsection 2.2.1.2.
- **Promote Load Balance:** If we manage to understand the local consumption, we can create means to promote challenges related to energy load balance, reducing the general consumption in peak times by helping the user to shift part of his consumption to another time of the day,

as long as this shift of the activity does not cause any problems to the schedule of the user.

- **Energy Consumption Measurement:** We plan to deliver the data for household consumption of energy to the users in order to allow them to keep track of what is going on at their place in real-time (not necessarily each second, but constant enough to see differences in consumption), using a smart meter reading his home consumption. By creating a mechanism that allows the user to check his current consumption, we will be creating a real-time(ish) way of displaying its current information, giving the user control of his own data. This functionality is based on what was previously discussed as direct feedback.
- **Multiple “User x Community” Integration:** We plan to create a multiple relation between a given user and the communities he is part of in real life. For instance, aside of his current city, the consumption of this user will be compared to the energy use of his coworker group, his own neighbours and users from similar households, which have a similar profile like him in matters of devices, behavior and size of house. The goal here is to give accurate comparisons between similar users in order to push them to save more, as it is shown in section 3.1.3.5.
- **Adaptive Saving Challenges, Hints and Tasks:** By understanding the user behavior, our application will trigger the challenges and tips that are mostly likely to help a given user. As result, we plan to give the user task that he can actually complete, hints that he can follow, and understand when to push more without having to tell him so, focusing on not making him lose interest on the application. After all, the user has to feel that this application was made for him.
- **Data Analytics and Machine Learning:** On the server side, a machine learning algorithm will take data from user into account (e.g. the type of a completed challenge, time to complete a task, how often the user checks the application, and etc.), and as result the application can relate behaviors to specific details, such as the kind of profile of the user, what works better in different city, etc. The goal here is to learn from user consumption behavior and suggests right smart actions.

4.2.2 User Functions of the App

Bellow, we list some functions that are integral and necessary part of the system, with objective of allowing the user to interact with the features,

other users, and which could generate value for them.

- **Promote Saving Actions:** The application should provide the user different actions he could take in order to reduce energy consumption. By selecting the actions he is more likely to take, this strategy could result in behavioral change. We name this function “Challenges” on the first versions of prototypes and “My Actions” on the new ones, including the implemented version.
- **Feed and Chats:** In the application, we should provide ways that the user can create a conversation about an energy subject. It should be interesting that the user could comment the tips and challenges on the pages of friends and could create topics on the communities they are part of. By doing that, we will be creating ways the user can solve personal questions, and increase the efficacy of that particular challenge/hint/tip, creating a link between a doubt from the user and the resolution of that doubt, prompting better results on the application level.
- **Community Management:** The interaction between users and their friends in a social context is a primary goal of such an application, and the communities in OSN can be a good place for the user to understand the profit of saving energy and being pushed to work towards common saving goals

4.3 Application Use

According to the notion of strong democracy proposed by Barber(1984) [8], democratic presence and cooperation cannot become a full-time job. Therefore, the users have to perform tasks often, but not have the obligation to spend time on the application. It would be interesting to provide fun to users, so they use the application because they want.

The lifestyle of users also is a catalyst for the use of the application. Masung et al. [35] found in his study that users with high scores on a pointification application were normally users with spare time, using their available moments to check the application. On the other hand, users without too much time available to be checking constantly the software were the ones with lower scores. Therefore, we should conceive an application which makes the usage time even, and provide means to efficient usage of time as well.

The application can be used as a checklist as well, so the user can save tasks he would like to perform daily and continuously take this action in order

to reduce energy. This would be a good method to feel behavior change, as the user will be inserting this action in his everyday task list, creating the possibility that, by taking this action on a daily basis, his chance of seeing a change on his behavior is increased.

Chapter 5

Methodology and User Studies

This chapter describes the methodology used to apply what was found during research into a prototype, as well as the tests performed and the evolution of the idea in order to create a full working prototype which can fit the initial goal of the project.

5.1 Methodology

As one of CIVIS future goals is to put in practice the outcome of the research, it would be interesting to use this possibility to imagine how this project could become a real application. We followed the ideas from Laura Klein’s book “UX for LEAN Startups” [32]. The objective is to create an application using LEAN¹, a methodology focused on delivering value to the customer in a maximized way and reducing waste of resources. This is a fast, clean, agile way to produce parts of a program, allowing multiple pivots and iterations. This methodology is interesting for startups and products in an early stage. In the above mentioned book, Klein discusses how to focus on the user experience using lean design.

The assumptions found during research were applied to the first version of our prototype. This wireframe version was used as support to the submission of this energy saving idea, by that time named EnergyAPP, to the Aalto Efficient Energy & Low Carbon Competition 2014-2015 (Aalto ENECOMP 2014-2015)². EnergyAPP was awarded 2nd prize in the Behavioral Changes category. This prize pushed us to work harder on a better conception of the prototype.

¹<http://www.lean.org>

²<http://www.aalto.fi/en/research/platforms/energy/enecomp/>

Afterwards, the features of this wireframe were improved after discussed with CIVIS partners, allowing some iteration on the features and usability. We changed the name to EnergyUP (test name) so we can refer to the application. Then, the first user test was made, in order to create some hypothesis for next test and iterations, obtained by qualitative feedback from possible users of EnergyUP. After the user test, we developed a new prototype, and iterated on it several times based on usability and concepts needed by CIVIS. Further meetings and Workshops with CIVIS researchers and results from other Focus Groups helped us to develop better the concepts from WorkPackage3 into a better looking version.

We designed an improved version of the prototype with the help of KTH University, a clickable version using pictures and JavaScript element to create clickable elements on the images. With this clickable prototype version and the concepts developed in this work, we applied with EnergyUP to Climate Launchpad 2015³, Europe's largest cleantech idea competition. The project was in Finland's National Finals of the competition.

Last, but not least, we created a full working model of the project using JavaScript with the help of KTH and TUDelft reserchers from CIVIS. With this version, we performed the second user test to understand the usefulness of the application.

Following we describe in details the conception of the application, from the first steps of conceptualization until the last tests.

5.2 Prototyping

In this section, we will show the functionalities previously discussed and their early implementations until the latest version. A set of images of the prototypes can be found annexed in appendix. For the sake of comparison, we will use images of three functionalities: challenges screen, feed and communities. This will give an idea of the iterations made on the prototype, resulting in the application we have today. Again, we used valuable hints on prototyping and LEAN methodology presented by Klein(2013)[32].

In the mock-up versions created in Balsamic, there are some "clicking hints" represented by a pink rectangle around the clickable elements. Those hints are not in all the versions due to the necessity of giving the user an idea of freedom during a clicking test. However, clicking hints can show the user which element he can interact with, and can be interesting, for instance, to show a prototype to an investor.

³<http://climatelaunchpad.org/>

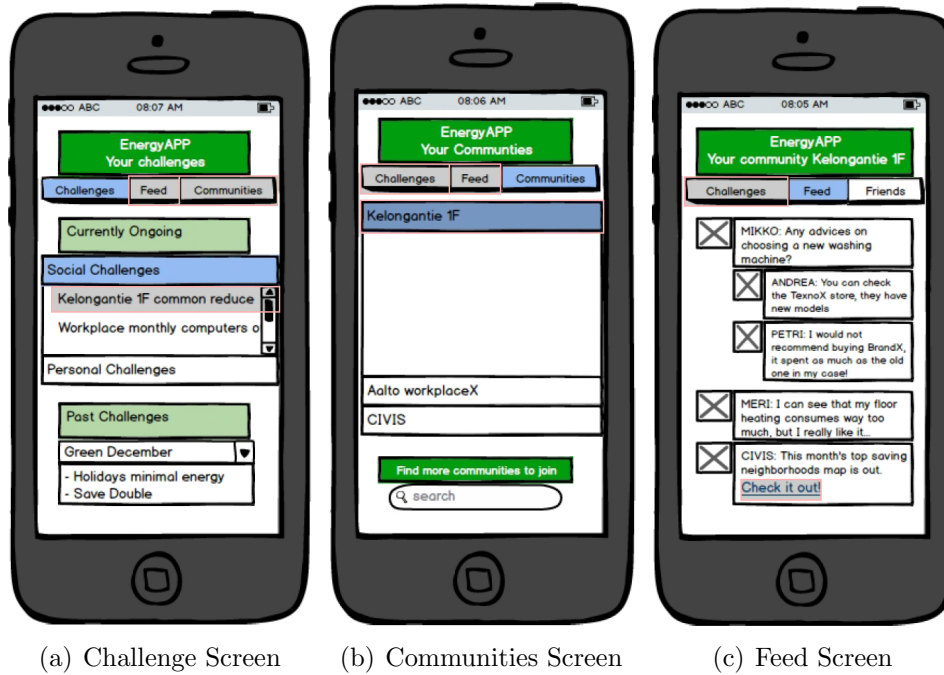


Figure 5.1: Screens of the first prototype of EnergyUP

5.2.1 First Version

Taking into account requirements of CIVIS, described in CIVIS DOW (i.e. Description of Work), we created the first prototype to deliver an example of our application. This version was created with Balsamic⁴, a useful tool to create wireframe mockups. This tool allows the creation of screen designs with clickable parts, exporting the result to PDF format. As shown in figure 5.1, the main functionalities of EnergyUP were already present since the first conception. The three main tabs are the Feed, Community and Challenge screens.

We created the Feed screen so the users could interact with each other, exchanging messages, nested according to the thread created. This concept of feed was used in all the versions of the mock-ups, suffering small changes after a couple of iterations (described in following sections 5.2.2.1 and 5.2.2.2).

As the proposed solution is a social application, we created a screen containing all the communities the user has joined. When this community is clicked, the user can see some details of it. The Community tab is present as main functionality of the application since this version.

The other tab present since this first version is the Challenge screen,

⁴<http://www.balsamic.com>

where the actions to be performed by the user are listed. These actions are presented to the user separately, splitting the challenges by its social characteristics (i.e. if the challenge is individual or social) or by its status (i.e. current and or concluded), as seen in figure 5.1.a.

This version of the prototype was more conceptual and less user driven. Nevertheless, it was important to understand how to balance the elements on the mobile application. The rest of the prototype can be found in appendix A.

5.2.2 Iterations on the Prototype

In this subsection, we describe the main changes performed on the prototype until the second user test, where a version was prepared focused on it. Some of them, vary in all the versions. Others, did not change all the time a new version was created. Nevertheless, we kept the screens in the pictures for information and comparison purposes.

During the current research, iterations on the prototype were made to change the user perception of the features. Some features, even if they are important, did not suffer drastic changes. For instance, the differences on the feed screen were not too big. This screen got pictures of hypothetical users and a look of chat, with nested replies and comments. Also, we describe some important details found on the user tests regarding features.

Bellow, we list the pivots created on the prototype that created changes on the screens and user functions of the prototypes, showing the iterations suffered from the first version to the last one on those capital functions, with focus on the Challenges (list of challenges and description of a challenge itself) and Community. More information can be found on the appendixes, where we discuss in more details the changes made on the prototype in appendix B. Also, we present a table to show which function is present to each prototype, in order to show the evolution of EnergyUP, in appendix C.

5.2.2.1 First Pivot - Prototype Version 1.5

We made our first pivot on the mock-up in order to make the application more real, closer to a working prototype for user testing.

After some discussions with CIVIS researchers, we decided to insert elements that could allow the application to provide more information for the user. As it can be seen in appendix C.1, the main pivots were on the display of information, setting up preferences and creation of new elements, in order to make EnergyUP more personal, tailored for each user.

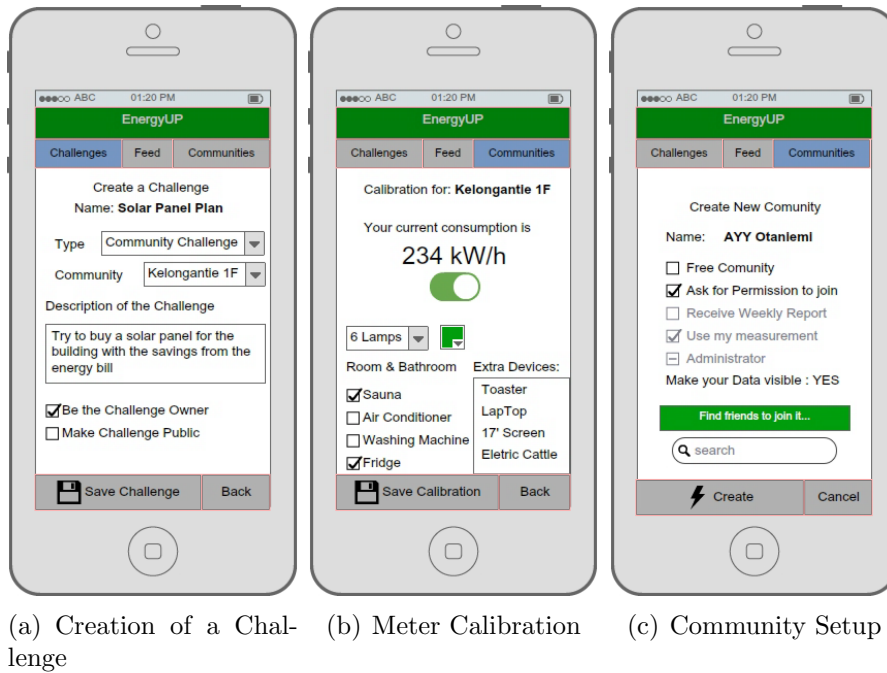
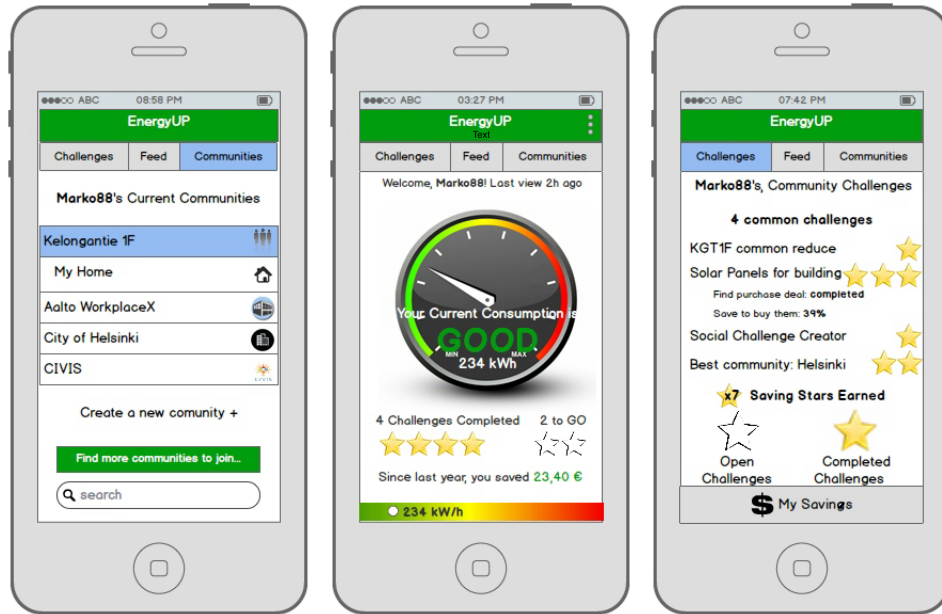


Figure 5.2: Setup screens on EnergyUP version 1.5

In this version, we created buttons to represent the creation of a community and new challenge by the user, giving the idea that he can customize and create items on the application. The possibility of customization also supported our idea of creating setups screens to the application. The insertion of setups, such as house calibration (where the user sets information about his house, for instance, how big it is and the type of appliances he has), user profile, and challenge type, have the goal of allowing user to set preferences on EnergyUP, despite of being dummy forms (where the combo boxes and items do not allow interactions or change in their state). The mentioned setups are shown in figure 5.2.

We also created screens to enhance the information delivery for the user. We created screens to represent the current energy consumption, the total savings of money and energy shown in an aggregated form, and graphics to display an analysis of the energy consumption. To support the deliver of information, we also created pop-up screens, showed after the user perform some operations, such as saving information, creating items, and etc.



(a) Icons in the Community Screen (b) Color Gradient in Main Screen (c) Pointification System

Figure 5.3: Pointification and icons on EnergyUP version 2.3

5.2.2.2 Second Pivot - Prototype Version 2.3

The second pivot happened after we submitted the prototype to researchers from CIVIS Trento. After some discussion, we decided to make some modifications on the prototype. This time, the changes had a focus on how the user sees the application, for instance, with the insertion of icons and testing buttons. We were preparing EnergyUP to be used in a user test, in order to attest if the users would understand the application, also with focus on the usability.

The first change we made on the application was the insertion of a login screen. In this screen, we inserted two buttons that led to the same place, the home screen. The first of the buttons, a green one, was representing the login using EnergyUP user ID. The other, blue, gave the option to the user to login with his Facebook credentials. The focus was to test if users in our test would use the alternative login, using their ID from an already existing Social Network. This would also help us understand if the users would be up to share information of EnergyUP in Facebook. The results of this test can be found in 5.3.1.

Another big change made from last pivot to this one was the modification of the Challenge list. In version 1.5 of the prototype, personal and community challenges were kept on the same screen, but in separated lists. Also, ongoing challenges (i.e. challenges the user are working on currently) and completed challenges were maintained on the same screen. Therefore, we modified the challenge screen in order to keep the ongoing challenges and the completed ones in different screens, but merging the social and personal on the same list, representing them with icons. In this version, we named as achievements the bigger picture of completing a series of related challenges.

Talking about icons, the pointification system proposed in 2.2.3.1 was inserted during this pivot on the prototype. We used stars to represent points rewarded to the user for his saving actions, and a light bulb with a leaf inside (eco-bulb) to represent achievements, which are a macro level of the challenges. Figure 5.3 shows the icons related to different communities and stars representing points.

Also, we tried to represent a top menu where the user could find the principal user functions of the system. In this way, the user could, by clicking an icon on the right corner find important screens faster. Another modification focused on the user perception was the insertion of a color bar, with gradient from red to green, representing the energy consumption at his household. On the main screen of the prototype, we displayed an energy meter to show the users the current energy usage at his house. This gradient as another way to represent the same function, without the necessity that the user is on the main screen. With this prototype, we performed the first user test, shown following, in section 5.3.

5.3 First User Test

We perform the first user test on EnergyUP using two prototypes. The first one, (hereby named prototype A) with a narrowed flow (see appendix E) due to dummy buttons, like a tutorial, full of explanation screens. The second one (from now on, prototype B), more complete, full of functions and working buttons in respect of the previous one. We used prototype version 2.3 as prototype B.

To perform the first user test, we created a simple version of prototype 2.3, containing one direct flow so the user remain on track and get some important information about EnergyUP. In order to test the creation of a user profile and insert his household information, this version had several dummy buttons make the user go in one direction. Also, pop-up texts were created to direct the user towards the next necessary action to be taken.

This version looks like a tutorial version, like the first stage of a game, where the user takes time to understand the environment he is in, and starts slowly interacting with it, receiving information to support his actions. Afterwards, we let the users play for a while with the complete version 2.3 of EnergyUP.

We performed this user to analyze the following:

- Whether they understand the purpose of the application;
- If there was any similar application they saw, with similar features or same purposes;
- If the users could complete the flow on the prototype A;
- Whether there was a pattern for issues or any navigation confusion;
- How was the interactions of users with dummy content, if they expect dummy buttons to work and if they clicked on them;
- What features should be built and are not currently present on this prototype;
- What sort of data would the user share on this app;
- The three most important features on the application for the user;
- If the participant have any questions regarding the application (if applicable);

5.3.1 Results

After studying the results of the test, we came up with the following conclusions.

- *Sign in:* Pretty much all the users of the test group signed in using email, not Facebook. We would need to research about this effect. However, one assumption we have is related to merging this information about login and the information about sharing data on social networks. The users would like to check what will they be posting on their regular OSN of choice, and also wondering about what kind of data it would be possible to fetch from OSN and use on EnergyUP. This possibly increased the use of EnergyUP login in comparison to OSN Login.

- *Winter jacket challenge*⁵: In general, the users of the test group liked it, so this was an unexpected success. It actually gave the user the idea that he can program the application to help him get something that materializes the budget saving, and is a personal reward in real life. The idea of interconnection with an on-line shopping to redirect the saving can be seen as an interesting possibility, but requires further analysis.
- *Flow*: Each users was lost a few times, so the usability of the application in this version was not considered simple enough. The hidden hierarchy of screens made the program look complex. Also, talking about prototype A, having an obligatory flow was not good as expected. People often used back buttons, showing clear lack of confidence. We understood that creating a version with the important features, but still as simple (maybe even simpler) is a must now, in order to give the user necessary confidence to use the application.
- *City of Helsinki*: Everyone liked the representation of communities representing a bigger level, such as a city. In this case, the representation of city level reports showed the users the city measurements levels, giving an idea of what the app does. This means that suggesting some communities, such as joining a community of fans of one's football team can have good acceptance.
- *Sharing content on Facebook*: We asked the tested users if they would like to share information on other OSN's, such as Facebook. Mainly, some people would do for the achievements and points, some would do it only if a challenge requires it. One of them said he would not, in any case, as he said he prefers not to complete this challenge than to be obliged.
- *3 Most Important Features*: Mainly, the reward system, the possibility of creating or selecting a challenge, and the comparison between communities were the most remembered.
- *Important Common Things*:

None has seen a similar app before, but similar features have been

⁵The strategy of calculating savings of the user and showing him where he could apply these spared money is not shared by CIVIS. They want to reduce the consumption and spending of people. However, we wanted to ask users if they see the energy savings were meaningful, by seeing a tangible good as result of household economy.

seen before, such as ranking and position system of users (WAZE⁶) and pointification with achievement system (Clash of Clans⁷) .

No one understood the purpose of the icons used in the application in the first place, enhancing the idea that the application has to be more intuitive.

The users in general said they would use EnergyUP (even if usability tests to promote changes is needed), and also that they would share their consumption, mainly if it does not expose the energy consumption separately, and mostly if they get consumption of others users (supporting group feedback).

The test was performed with 8 users, and all of them were members of Aalto University Staff. Mostly, they formed a heterogeneous group in the matter of birth place (all of them belong to a different country), but homogeneous in matters of educational background (professors, students of PhD. or MSc. degree). We asked co-workers and classmates to help on the tests, and taking about 20 minutes, on average, under supervision. The results and complete table regarding this test can be found in appendix D.

5.4 Implementation

In this section, we discuss how the first user test helped us to iterate and create another pivot on EnergyUP and come up with an implemented version to be used on the second user test.

5.4.1 Third Pivot - Prototype in JavaScript

With the results of the first test, we modified the prototype to fit the user expectation. Due to that, the version 3.0 of the prototype was created, following the same style of previous versions.

This version was shared with KTH research group, and a fast iteration happened to a completely different version. A clickable version, using pictures and JavaScript, was created, having different color schema and interaction with the savings tasks. This was the biggest pivot EnergyUP suffered, mainly on the look of the application and the display of the functionalities. The main differences of this version are:

⁶<https://www.waze.com/>

⁷<https://clashofclans.com/>

- *Namings*: The “Challenges” are now called “Actions”. This name represents more the idea of the user taking some initiative to do something, and its less related to a possible struggle to perform.
- *Pointification*: The saving stars were replaced by leafs, in order to make the application looks more environmentally appealing.
- *Action Feedback*: A feedback section was created in each action, so the user could inform how much effort was necessary to perform that given task. The feedback is also present when a user cancels an action.
- *Household Tab*: In this tab, the user can see what actions are being performed by the persons which share the household with him. This creates the role of modelling, where a given user could select an action which others are performing and add to his list.
- *“See what others are doing”*: In this version, it is possible to check what action your friends are taking in a personal level, but also see what are the top actions (i.e. actions a large number of users are taking). This functionality could help the users to adhere to some type of actions, as most people are doing as well.

5.4.2 Design of the Test Application with Ionic

From this version on, we created a working version, based on the JS prototype. To make it platform independent, we used Ionic⁸. This framework aims at producing fast, platform independent mobile applications using HTML5 and AngularJS to create the content on the screen. Also, we used Firebase⁹, a JSON database that enables syncing data in real time, to store the content shown and modified by the user. With this solution, we created not only a clickable version of a prototype, but a real looking application.

One of the problems of the other prototype versions created with Balsamic was the lack of changes on run time. In other words, this type of prototype tool do not allow saving the current state of the application. For instance, let us say the user completed a challenge, and he will see it vanishing from the challenge screen. This new state of the screen will only be maintained if and only if all the other screens that led to the challenge screen were doubled to take the user to this second state of this screen, with one challenge less. This creates a lot of useless duplicated screens and increases drastically the size

⁸<http://ionicframework.com/>

⁹<https://www.firebase.com/>

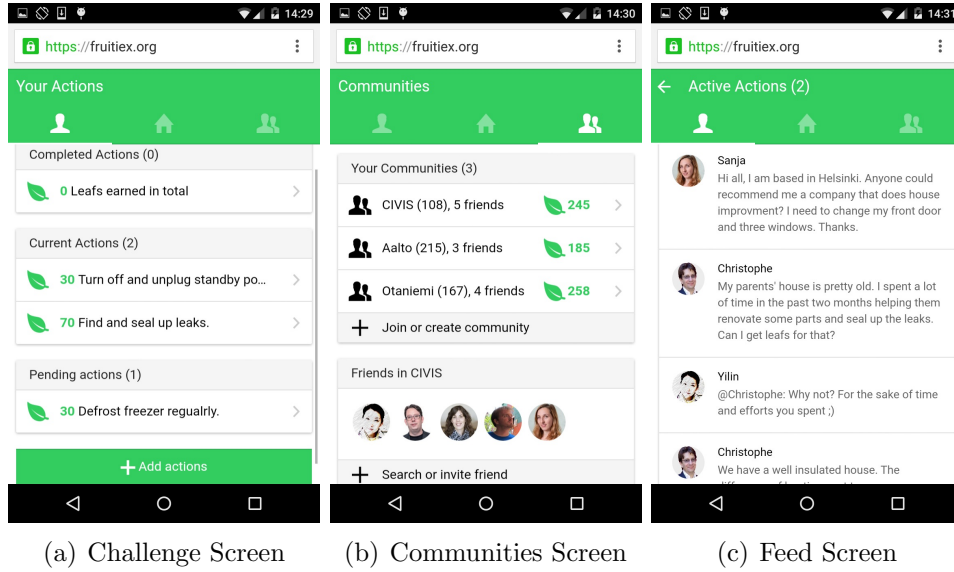


Figure 5.4: Screens of the implemented version of EnergyUP

and effort to create a real interaction between the user and the application. With Ionic, this problem does not happen anymore.

This version of the prototype can be seen in appendix F, where figure F.1 contains the screens of this working version.

In comparison with figure 5.1, which contains the Challenge (now called Action), Community and Feed Screen, figure 5.4 shows the final implementation of these screens, showing the final stage after several changes.

According to session 3.1.3, saving strategies based on social interventions are more influential to push behavioral changes on users. Therefore, saving interventions based on social principles should have a decisive role on the proposed application, giving base to the features and being an important part of the implemented version.

To design EnergyUP, we selected features to the application which supports six approaches based on social influence aiming to energy conservation. Following, we describe the features and how they reinforce the selected social approaches. This implemented version is the one used for the second user test.

5.4.2.1 Features to be Tested

The user functions we selected to be tested on the second user test were chosen based on the social influence we wanted to test, and implemented

the features to fit the user test. Following, we present the social strategy selected, how we planned to test and the feature where this strategy was implemented.

- *Public Commitment*: When a user selects a number of actions and challenges to be performed, as well as saving tips he wants to follow, those selections would be made visible when he adds them to his profile, so his friends on the network would be able to see what that particular user has committed to do.

Feature: Selection of a set of tips to be performed and marking a tip/action as completed and rate it according to the effort made and easiness to complete

- *Modelling*: The proposed application provides several ways to implement modeling as social influence. The application supports modelling behavior by exhibiting the behavior of other users. In this way, by creating the role of a block leader, respected community members and well ranked users in the social circle, the community can visualize the actions they are taking, which tips they are following and how much savings they achieved. On the household level, completing multiple actions can generate the same effect, making the user become a model to their family or flatmates.

Feature: Previewing the profile of a friend/community member

- *Group Feedback*: The measurement of collective efficacy in savings, as well as the progress of the community in common challenges is given to the community as group feedback.

Feature: Previewing the achievements of the community

- *Use of Social Norms in Feedback Provision*: In the proposed application, social norms would be settled by sharing information about “what and how similar households are doing”, for example. Also, the content of saving tips as well as the most popular actions on the community will also serve to improve behavior of the users.

Feature: Preview of the most popular actions on the community’s action list

The following features are partially implemented on the first working prototype, used on the second user test. However, due to specific reasons, they could not be tested. Following, we discuss the features and the reason they were left out of the user test. Nevertheless, they are important features of the application, and should be part of the integral version in any case.

- *Block Leaders and Social Networks*: In order to enable a block leader to exercise influence on other users, we would have to implement ways that a user could send information about certain tips and challenges to others, whenever they want to inform or share content with them. As the idea of the proposed solution is to create a social energy network, this feature leverages social influence through empowering strong social ties.

Feature: Sending tips to friends or to the community

Reason for not being tested: There is still some issues with visualization parts of the user profile. If we could implement a version where the user could have a level, this feature could be tested. The communication part, between two users, is also not implemented. Therefore, the interaction between two users could not be tested.

- *Socially Comparative Feedback*: As the users are able to see their performance and compare themselves to the results of their friends, coworkers and community members, the feature that allows comparative feedback in social level is integral part of such system

Feature: Compare your savings with your friends

Reason for not being tested: There is still a need to implement a meaningful comparison to friends. In this prototype version, there is no concept of ranking, so comparisons cannot be made. As stated on the on the previous case, the interaction between two users is not working yet. Also, the energy data visualization was also missing, making the comparison and display of the user consumption an absent feature in this version.

5.5 Second User Tests

With the Ionic JavaScript working prototype, we decided to perform a last user test to confirm the acceptance and the usefulness of the application. The focus was not to test the usability of the program, despite of the possibility to receive feedback about the usage.

To test how useful is the of the application, we used the Technology Acceptance Model, which includes also attest the ease-to-use perception regarding the user experience. This model was proposed by Davis (1989) [18], and since then it has become a powerful well-established model to confirm and predict user acceptance [45], specific to explain the user behavior in computer systems [18].

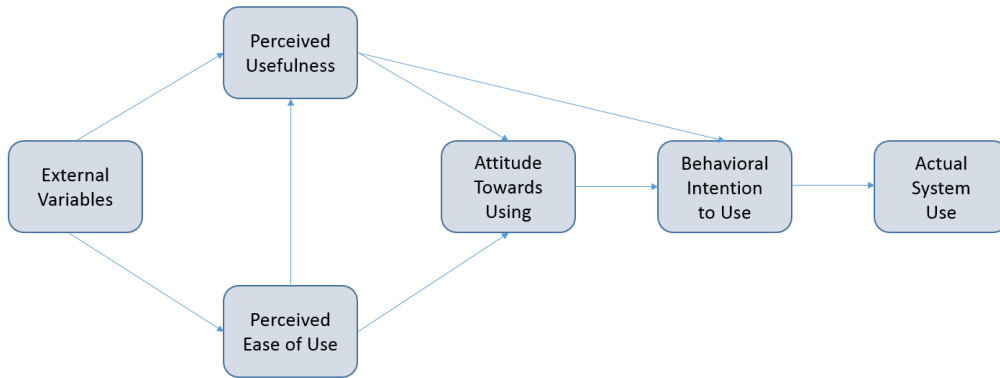


Figure 5.5: Technology Acceptance Model (Davis 1989)

The theoretical basis of TAM implies that the behavior of the user and the intention to use a solution is influenced by two factors: *perceived usefulness* (PU), which is, according to Venkatesh and Davis (2000) [45], defined as “the extent to which a person believes that using the system will enhance his or her job performance”, and *perceived ease to use* (PEoU), defined in the same article as “the extent to which a person believes that using the system will be free of effort”. These two variables are highly important as primary motivational reasons for the usage of a new technology [18]. The figure 5.5 shows the TAM proposed by Davis (1989) [17].

We adapted questions proposed by Nolan, Schultz, Cialdini, Goldstain and Giskevicius (2008) [40], to understand user perception and in the end, we used an adaptation of the questions proposed by Davis (1989) [17] to understand how the users find the application useful and ease to use.

We created EnergyUP test site for demonstration during the Open Source Circular Economy Days - Helsinki (OSCE2015¹⁰), an event that promotes sustainable circular economy using open source solutions. The target of the test was random people which were passing by or were taking a look at our test site and received an invitation to test our application, in an approach known as Guerrilla Test [32]. Also, some users could subscribe on-line for the test using the OSCE website. We tested 24 individuals during this day.

The complete set results, with graphics generated by Google Forms¹¹, can be found in the appendix G, in the end of this work. In the following subsection, we analyse the quantitative answers, regarding the information about the users, the tested scenarios and the Technology Acceptance Model.

¹⁰<https://oscedays.org/>

¹¹<https://www.google.com/forms/about/>

Testing scenario II, which is related to Modelling, was composed by qualitative questions, so it will not show up in the following sections. Also, it is important to remind that, when questionnaires are used and they involve an aggregate score, only that is reported. Nevertheless, we analyse some of the variables independently as well in order to discuss the perception of users regarding some aspects of the application.

5.5.1 Type of Users

The average tested user is 39 years old (ranging from 22 to 57), dominantly right-handed (91.7% of the cases) and sharing the house with 3 persons on average. About the type of house, 62.5% of the users live in residential building apartments, in a 30 to 50 square meters (43.5% of the cases).

The users were also asked about their familiarity with touchscreen technology. The answers on the questionnaire varied from a little familiar (0) to totally familiar (7). We found that the big majority is indeed comfortable with touchscreen, as 54.2% replied they are totally familiar and marked 7 as option, followed by 25% percent which marked the second highest option, 6.

Our users had very different type of jobs, and we found that, among the ones that informed us their profession (58% of the total users which tested EnergyUP), 28% of them were related to academic research.

We had a technical tie on the gender (54.2% male and 45.8% of females tested), which is good for our statistics.

5.5.2 Scenario Results

In our user test, we had the opportunity not only to get the answers from the scientific questions proposed by Nolan et al. [40], but quantitative and qualitative feedback and replies. Some of the users gave feedback on the features and usability. Even if this was not the focus of our test, the opinion of potential users can help our application to become better and more accepted.

Replying the question about how often the users try to save energy, 41.7% said they almost always do it, followed by people that states they frequently save energy (33.3% of the cases), and that do it sometimes (in 25% of the responses). No user said he never take saving energy measures. We could attest how pro-green causes our target group was on this test. Mostly due to the place they were, as OSCE events are focused on sustainability.

In the next questions, the queries were related to how important is the consequence of his action for the given user, when he decides to save energy. The answers were rated from “Not at all important”, “Somewhat Important”, “Very Important” and “Extremely Important”. We could attest that, for the

users of the test, it is not totally important on the first look that using less energy prompts monetary savings. We found that the big majority (65.2%) considers it somewhat important. The same amount of users informed it is extremely important and not important at all (13%).

When it comes to saving energy to protect environmental resources, the big majority (56.5%) replied that it is extremely important, followed by very important (30.4%), with the rest of the users saying this is somewhat important. We could attest that the environmental protection should be a major goal for saving energy, and this could be used to promote energy reduction if we relate saving strategies and tips to raise environmental concern. About benefiting society as consequence of saving energy, we could attest that none of the users actually thinks that this measure is not important at all, as 0% replied that this is not at all important. For the majority, 47.8% of the users, it is considered very important that society benefits from energy savings.

The social engagement question had close results. We found that it is “Extremely important ” that other people also try to save energy for 39,1% of the users. Answers such as “Very Important” and “Somewhat Important” had similar results, 21.7% and 30.4% respectively. Despite of the technical tie between the options, we can see that social engagement is important, but its importance is more crucial to some users than to others.

Next set of questions were related to how much the users think a given action (conserving energy) can be effective in producing a desired outcome (for instance, benefit society). The answers ranged from “1 - Not at all” to “4 - Extremely”. When users were asked how much they think conserving energy will benefit society, the extreme majority confirmed that saving energy, in their opinion, can have great profit for society, as 65% responded that they think society can benefit extremely (rate 4, the highest), followed by 30.4% (rate 3, second highest). No users said that society will not profit at all from energy saving actions.

The second question was related to how much the user thinks saving energy protects the environment. Again, the majority confirmed that natural environment can be extremely protected by energy saving actions, with 56.5% of the users marking 4, followed by 39% of the users which marked 3. Again, no users marked that there will not be any profit for nature if energy reducing measures are taken.

According to our study, users were found skeptical about two subjects: saving money by reducing energy consumption and if they think the others try to take energy saving actions oftenly. When asked about how much money they can actually save by reducing energy consumption at home, users marked 2 and 3 as the major choices, with 39% and 34.8% respectively, followed by 1, not at all, in 17% of the cases.

Also, users were skeptical about how often they think their neighbours try to conserve energy. Users marked 2, second lowest grade, in 50% of the cases, followed by 1 (not at all), in 27.3%. The same effect happened when we asked, instead of neighbours, if they think their family members try to conserve energy often. Most of the users replied “frequently” and “sometimes”, in 56% and 30.4% of the cases, respectively.

High results, but similar to the skeptical numbers previously mentioned, were found when we asked users if they think that residents of the city and Finns in general usually try to save energy. For 82% of the users, the residents of Helsinki sometimes save energy, and 17% thinks they frequently perform saving actions. When it comes to the opinion about the Finnish energy saving behavior, 78% replied they think Finns sometimes try to save energy, followed by 21% that thinks Finland nationals frequently try to save energy. In both questions, no users replied “never” or “always”.

5.5.2.1 Scenario I - Public Commitment

In the first proposed scenario, we tested Public Commitment, allowing the user to mark multiple options if they feel like.

In the questions after the user interacted with the actions of the application, selecting some of them to be exhibited in his action list, we asked the users about what is important for them regarding the actions we plan to propose on the application.

The users marked that they would like to “see the impact of the actions”, option selected in 70% of the cases, followed closely by “Easy to Perform”, chosen in 66% of the situations. “Daily Routine” actions was the option selected in 29.2%.

We also asked the users who they would be willing to share the saving actions with. In 41% of the times, the users said they would share their actions with anyone. The next options, “Friends” and “Family” both had 29% of public selection. This shows also the possibility of creating block leader and modelling roles, as sharing the actions the user is performing with close friends opens the possibility to defining this roles. Interestingly, users only selected Community option in 4.2%. Also, not sharing their actions with anyone was selected in 16% of the cases. The last two numbers show that people felt already the public commitment, and the uncertainty of being judged by their weak ties (i.e. by someone they do not really have friendship). In any case, Public Commitment works better with strong ties, and the results found shows that commitment can be created with EnergyUP.

5.5.2.2 Scenario II - Modelling

The second tested scenario was related to modelling. We showed the users the second tab of EnergyUP, where the users could see the members of his household and the saving actions on their list, and asked them to interact with it in order to understand what is the purpose of this screen.

The answers in this section were qualitative, with three open questions. The first query asks the user what he thinks about the Household Actions list. We got 19 responses to that question, seven were negative feedback. The critics were concentrated on the similarity to “My Action list”, where the users questioned why both tabs are separated, creating a bit of confusion. In some sort of way, it is understandable. Currently in this tab, a message bellow an action (performed by a household member) shows the user that “you are also doing this action”. Therefore, on “My Action list” it could be created the same feature the other way around, saying bellow a given action that a member of that household is already performing that action, not only how many users added that give action to their list.

However, the biggest part of the users informed they understood the purpose of the separation of both tabs. They said it is a good way of controlling their household, spreading saving actions among the family members, and creating a relevant way to share ideas and create a useful comparison between what the other relatives and flatmates are doing. Some of the users highlighted that having the same action set for different members of the household can make the end goal look easier to tackle, and mainly that the performance of the others can motivate positively family members towards common energy saving objectives.

We asked the users whose details, and what type of information they would like to see in this part. We also received 19 answers, but this time they covered more subjects.

The tested users said, in general, that they would like to see information about their friends and family living in the same place, and also information from neighbors (as long as they accept it as well) mainly the ones living in households of the same type and style (e.g. apartments from the same building), with similar life standards.

When it comes to the type of information they would like to see in this place, the users stated they would like to see the energy data, mostly in form of graphics and icons, in order to provide them information about their success and the progress of the actions.

The users mentioned they would like to see some little variations on this screen. Some users mentioned that they would like to see agreements made between their family members on the household, not necessarily to control

how they are doing, but to keep track of what they chose as a common objective. User also mentioned the possibility of aggregating the actions that are similar in some sort of context.

The last question of this part asked the user to give free comments regarding the current tab. We received 12 responses. The answers were mostly unrelated. In general, the users commented that the actions present in this tab should be different, closer to an action for the group that lives in the household (a common objective). People also demanded for a clear, easy-to-use design, as some of the users were confused with the same actions showing up both in his action list and his household tab.

Some users also gave interesting ideas, such as creation of reminders and ways to create peer control, so parents can push the behavior of their kids even more. Also, users requested to see a bigger sense of priorities on the actions for the household, such as different colors for high priority actions, to create a better experience between users and their relatives.

5.5.2.3 Scenario III - Group Feedback and Use of Social Norms in Feedback Provision

The third scenario tested was the Group Feedback and the Social Norms in Feedback Provision, where the user could interact with the Community tab and check the communities he has, the different friends which are members of each community and the top actions (i.e. the actions which are being performed by a large number of users) in each community.

The first question was asking what kind of communities the user would be willing to create or join. According to our test, the option with biggest acceptance was friends, marked in 83.3% of the cases, followed closely by family (70.8%) and colleagues (58%).

Regarding the goals and challenges the user wants to participate with the community, the users replied that “save money together to invest in solar panels or other common goal” is a good idea, and was selected in 65% of the tests, followed closely by “saving a percentage together with the community” (60.9%). “Compete with other similar community” was chosen in 26% of the situations.

Also, we asked the users what kind of feedback they wish our application could provide them. We found that the “amount of energy saved” is the alternative most selected by the users, marked in 82% of the cases. In 47.8%, the “top actions taken (among friends or in the community)” was selected. “Leaf points” was selected by 21.7% of the times by users.

5.5.3 TAM Results

As show in the section 5.5, we adapted questions proposed by Nolan, Schultz, Cialdini, Goldstain and Griskevicius (2008) [40], to confirm that the application is useful and easy to use. The user could select a number from 1 to 7 to represent how he agrees with a proposed affirmation, where the lowest score (1) represents “Extremely Likely” and the highest score (7) means the users think this affirmation is “Extremely Unlikely”.

We can analyze the results of the user test in separate or in aggregation. This way, we can evaluate the response of individuals prior to create a group analysis. We used four different ways to analyze each variable individually: a) the mean value of each PE and PU variables separately, as used by Guerreiro et al. [27], b) if there were more users before or after the center of the scale (not considering the center value, which is 4), c) the most selected options for that given variable, and d) whether the lowest or highest value were not balanced between each other. Following, we discuss each variable and the results found on this study.

5.5.3.1 PU Results

The first set of affirmations had the objective of defining EnergyUP’s perceived usefulness (PU), and we gave four sentences to 24 users which tested EnergyUP in OSCE. The results of this test can be found in the appendix G, shown if figure G.7.

- “Using the EnergyUP app would enhance my effectiveness on *reducing energy use*”.

To this affirmation, we had average around 3.96. However, 10 users had marks bellow the average, and the most common response was 4, with seven users marking this option, representing 29% of the users. We had three highest scores (7) but only one mark on the lowest score (1). The final score for this variable was the highest we had as an average of the values of an affirmation alone for the TAM test. Yet, the average show that users are not clear that EnergyUP can enhance their effectiveness on lowering the energy consumption.

- “I would find the EnergyUP app to be useful in *reducing energy use*”.

The average score for this affirmation was the lowest among the PU test variables, reaching 3.21. For this affirmation, we had 15 users marking bellow

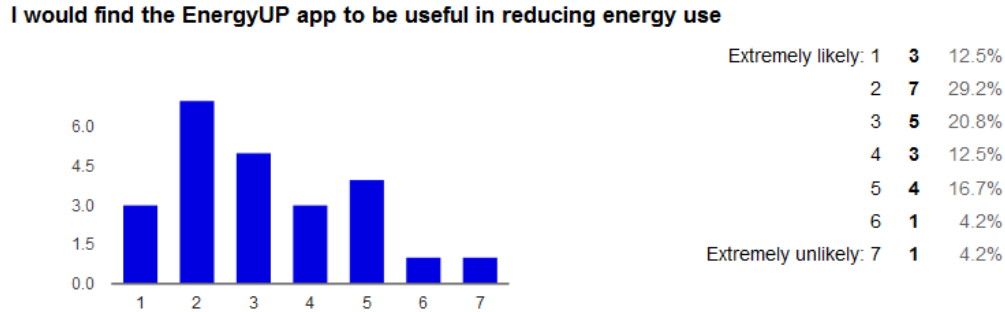


Figure 5.6: User Test result of one variable of Perceived Usefulness

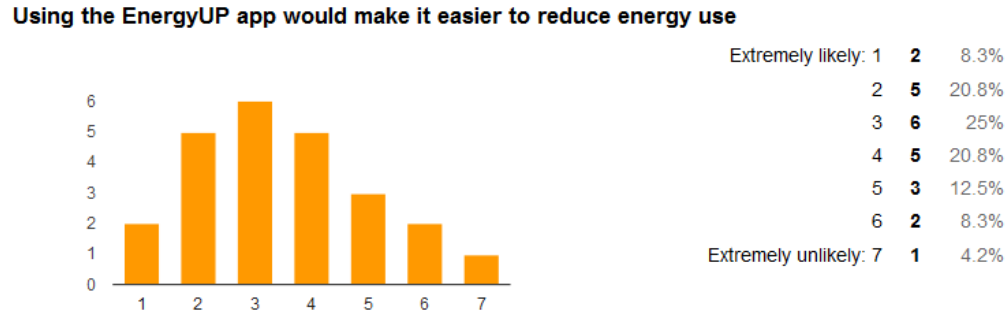


Figure 5.7: User Test result of another variable of Perceived Usefulness

the average, and the most common response was 2, selected by seven users. Only two users selected values above 5, and only one user selected the highest value (7), where three selected the lowest, as it is possible to see in figure 5.6. The result shows that it is likely that the application would be useful to help reducing energy use.

- “Using the EnergyUP app would make it easier to *reduce energy use*”.

The scores for this affirmation were concentrated on 2, 3 and 4 (with five, six and five occurrences, respectively, representing more than 65% of the users), and thirteen users marked values bellow the center of the curve. The average value of options for this variable is 3.5. This can be analyzed as if the users find that EnergyUP can make it easier to reduce the consumption of energy, as it is possible to see in figure 5.7, the distribution of values are more concentrated on the lowest values of the scale.

- “Using the EnergyUP app would improve my performance in *reducing energy use*”.

For this variable, the average value found was 3.67, with 13 users selecting values bellow 4. The highest occurrence was 3, marked eight times (39% of times) by the users. Once again the distribution was concentrated on the left side of the scale, where the lower values are. Despite of that, the average value for this variable was the second highest among TAM average values.

5.5.3.2 PEOU Results

The second part of the TAM test had the goal of understanding EnergyUP's perceived ease of use (PEoU, or just PE), where the 24 users had the same type of questionnaire from the PU test, grading four affirmations. The results of this test can be found in the appendix G, shown if figure G.8. Bellow, we discuss the PEOU variables and the results found on the test.

- “Learning to use EnergyUP would be easy for me”.

This variable had the lowest average value for all the TAM questions, reaching 2.54, which is an interesting value. Eighteen users marked values bellow the average, and the lowest value (1) was selected by nine of them, and no users marked the highest value. The average of users were densely concentrated on the left side of the scale, with 67% of the users marking values 1 and 2 for this affirmation. This means the users think that it is very likely that learning how to use the proposed application will be easy for them.

- “My interaction with the EnergyUP app would be clear and understandable”.

The scores for this affirmation were concentrated in two values. Around 39% of the users marked 2 and 26% of the users marked 5. There were 15 users marking values bellow the middle of the scale, and the average value was 3.17. On the open questions, we found that some users found the purpose of the functions of application understandable and some were a bit confused. This result corroborates with it, showing the polarity on the graphics, as show on the green graphic in the G.8, on the appendix G.

- “I would find the EnergyUP app to be flexible to interact with”.

The answers given by the users for this part formed an interesting, even, but bimodal distribution, where two peaks of users were on values 2 and 5, both with 20% of the users. The average value was 3.54. For this affirmation, we can say users are not certain about the flexibility of EnergyUP, but tending more to believe that the application can be flexible to interact with.

- “I would find the EnergyUP app easy to use”.

The last question of the perceived ease of use had average value 3.20, where fourteen users selected values below 4, accounting 58% of the users. The most selected values were 1 and 2, each with 20% of the users. However, the distribution was slightly even, even if no users selected the highest value. We can attest that the users think the application is easy to use.

5.5.3.3 Discussion about Test Results

In aggregation, we merged values in two ways: grouping values from the same user and grouping values from each variable (PE and PU). We evaluated the results in three different ways: a) calculating the PEOU and PU per user, b) the TAM value per user, c) the final PEOU and PU variables and d) the final TAM value.

For the PU variable, we calculated the average value marked of each user for this variable. We had the 16 values lower than the center of the scale. The aggregate average value for the PU variable was 3.58. As said on the previous section 5.5.3.2, the users were generally concentrated on the lower values of the scale, with good answers for the queries regarding EnergyUP being useful in reducing energy use, that users think the application can improve their performance, and making it easier to lower the consumption, due to the distribution of values on the left side of the scale.

For the PEOU, the average aggregated value for all the users was 3.11, again with 16 values lower than 4. This result was considered good to show that, for the average part of the users, they think it can be very easy to learn how to use the application, and that is somewhat clear to interact with EnergyUP.

By merging the results of PEOU and PU per user, we found the TAM score for each user, which is 3.34, where 17 users had average value of their TAM score below the center of the score line. Nevertheless, there are three important remarks on this study.

The first one is that it is interesting to cross the values found on the TAM test with other questions of the test, in order to find important patterns and further subjects of study. We had polarization in some of the questions, so we could see that some users had a better impression of EnergyUP, and others found the application not so easier to use. Therefore, understanding which kind of user had different impressions can be profitable for next versions of EnergyUP. The analysis presented on this work can become a paper, which is one of the future plans (see section 6.2).

There was a clear pattern between the score for perceived ease of use and perceived usefulness. Users that, in average, had the perceived usefulness score above 5 also scored the same on perceived ease of use. This also corroborates with the idea that these variables are interconnected.

Also, we currently found that the majority of the users had scores closer to the lower part of the scale than the higher scores. This shows that the user found that the application is likely to be useful and easy to use, but the users are not yet positioned about the application. It would be interesting to compare the results of this TAM with the ones found in next tests of further versions, in order to compare the usefulness of different applications, as proposed by Guerreiro et al. [27].

Chapter 6

Discussion

During the research described in this document, we worked to observe what were the most effective strategies found in the literature and apply them to our prototype and tests.

In the author's point of view, applying the correct energy saving strategies on the software itself is not the most complicated issue, but understanding what strategy is most likely to be followed and taken into account, which depends on different factors.

Strategies can produce different effects on users, as normally even on a given group (e.g. a class from the university), homogeneous in background, can have different results due to the heterogeneous types of members, their beliefs and the demographic factors.

Nevertheless, if the entire solution is well implemented, this work can become a strong tool to predict the actions which should be considered to a given user at a given time. We would need to test it on the proper means, i.e. get enough data, so we can have an application that truly works predicting, suggesting and advising the user with information suitable for him. Therefore, having the user data analysed so we can deliver tailored information is crucial to understand how effective one action taken by a user can be applied to another user with the same profile.

It is interesting to notice the huge number of variants to be analyzed in this work and, in the particular case of this thesis, can become a valuable tool to create engagement. For instance, even if a saving strategy, on the literature, is known for not being very successful all alone (e.g. price of energy), this feature could call for the attention of the users if an interesting event happens, (i.e. the increased production of, for instance, solar energy, reducing the price of energy). Users could start commenting about it and about how to profit better from such situation. In this case, we can depict clearly the use of a saving strategy not to promote savings directly, but to

create awareness and possibly reaching different groups of users in order to enhance knowledge and build new saving strategies.

The most important part of this work is to use correctly the help of social networks to create different feelings on the user, mostly implicitly, so the user can be pushed to save energy. The stronger and real are the ties created in EnergyUP, bigger are the chances that the interventions are effective. It should be, then, interesting to have contacts list extended from other social networks, if possible.

Allowing the savings of energy to be accounted in a community level can make users pressure others in real and virtual environment. The role of block leader is important, and the proposed application can support the creation by a reward system where an efficient user levels up.

Also, the benefits of social pressure caused by known friends, as well as the implicit social norms attached to the challenges, can encourage users to save more. If the theoretical part is well implemented, the results of the combination of strategies can produce an interesting effect.

One interesting functionality of the system is the possibility of creating social groups with similarities in different levels, and in the end, to deliver the most suitable activities for them. For example, the system could understand that similar buildings on the same street can become a cluster, where the homogeneity is based on the similarity of the building structure. Or also, apply similar hints and challenges to similar social classes, homogeneous by demographic factors. On a bigger level, we could understand the effects of a given action on this group, discerning how effective an action was in a socially homogeneous group. Strategies that work in one place could work on the other, increasing the energy saving results in the end.

The user tests revealed that the users have different interests when it comes to saving energy. We could see that the users also do not believe that the others have frequent saving attitude towards saving practices, and this application can show them that the users actually are engaged on this kind of causes.

The user tests also show that the application can have a positive effect on the users, and the profits to the society and mainly to his community can create the necessary engagement. Nevertheless, we found that users think that an application such as EnergyUP can help them to achieve the energy saving goals, as long as it is tailored for their needs.

6.1 Answers to the Research Questions

Following, we wrap up the discussion presented along this work, in order to give answers to the research questions presented in the beginning of this thesis.

- How we can improve the behavior of users and make their everyday consumption more efficient?

This question is answered from literature review for now. Therefore, during our research, we found that there is a big part of the energy spent in households which is considered waste, and the users can take advantage of energy saving strategies to improve their consumption. However, the saving strategies normally are concentrated in ineffective ways of informing the users, without any commitment to the user itself.

We showed in this work that saving strategies have a strong effect on influencing behavior, mainly if the correct one is selected and tailored to the user needs. Those strategies can prompt users to increase the amount of energy saved, as they are encouraged to do it by seeing real results and real improvement.

The behavior change comes with the commitment from the user, as they have to want to change behavior by seeing the benefits of it, and to repeat the correct actions, forgetting the incorrect ones. Therefore, we are providing a tool to create both effects on the user, where he can see the results of an enhanced behavior in a positive way. We are also helping the users to understand the misuse of energy, guiding them to take the correct actions to change it.

- What special gains ICT and the current mobile technologies can provide?

Information technology networks provide the necessary scalability to the application in order to reach multiple users, being an important part to interconnect the social and the energy networks, as shown in figure 2.1.

Mobile ICT fits the role of IHD, important tool to create awareness of the energy consumption according to [14],[23]. This way, the user can feel in control of his consumption, having a way of checking his energy consumption whenever he wants.

The technology available today allows the connection between devices and (mainly between) users, providing a way to create the necessary energy saving network proposed in this work.

- How interactions or inter-dependencies between individuals increases or decrease their engagement on the practice of reducing energy consumption (and in particular, in the case of interactions based on challenges)?

In this work, we discussed about different social based saving strategies presented in the literature. In our second user test, we could show the users how the application would work based on social context, adding implicitly the feeling of social pressure to drive users to take actions by the creation of commitment. On our tests, we could see that users, which are normally skeptical to the efficiency and frequent attitude towards saving practices from others, can be benefit from this application, which can show them that others are actually engaged on this kind of causes.

This feeling of social pressure is present in our daily life, and by integrating this feeling in our application, we increase their need of creating social proof that they are committed to the actions they adhere to, and also create pressure to others, by being able to see their actions.

The users also can see how (and what) their neighbours, family members and friends are doing, so they can check what kind of strategies can be more effective to his household or his consumption style. The users can, therefore, select the actions which are most likely to work with him, enhancing the savings of energy.

6.2 Future Work

When it comes to the possibilities of extending this work, we think that some improvements would help EnergyUP succeed even more. Bellow, we list some possible future features that could be implemented in the system, boosting the effects of an energy saving social application.

As stated by Faruqui (2010) [23], the prepayment of energy can be beneficial, as it can produce twice the savings of energy, mainly due to the fact that the user already gave money to the utility, and can get a slice back if he reduces his consumption. Therefore, we could project creating relations with banks or even the utilities. The most difficult step would be to convince the user to adopt a prepaid strategy. In markets which allow prepayment of energy, this strategy could be applied to produce even better results. If we could give the users an option of buying a tangible thing with the savings, like a solar panel (on a community level) or some household appliance (personal level), we could not only create another revenue stream, but also to help users to see their savings of energy becoming a real thing.

Other interesting addition to this application would be to insert weather information. Weather can influence the energy production [31],[39], and creating a way to understand this could make the users schedule its energy consumption activities on those days of intense production, as well as reduce it and load balance in the other case.

On the market side, from time to time new energy efficient appliances are created, and their effect can also promote savings of energy a bit further. It would be interesting to give the user notification when a new efficient bulb or other saving device has reached the market. This copes with the idea that the energy use can always be reduced.

It would be fairly interesting also to deliver a mix of budget saving advices, and not only saving tip related to energy. By mixing these strategies, we could provide the user how much will he save in two different ways. Overtime, kW/h is the most reliable comparison unit by far, but is seen as irrelevant in comparison with cost in the first place [16].

EnergyUP could also achieve credibility by selecting partners such as energy companies, energy efficient household appliance manufacturers or companies focused on green causes. Having cooperation with such partners would help us to create different roles of block leaders or models.

On the research field, we could test the application with a different cultural group, to see if the assumptions were correct or not. The tested group used on the first test (young persons, mobile friendly with academic background) and the second one (environmentally concerned people) were different, but a more general sample would provide interesting results to a test.

Also, it would be possible to create comparison between EnergyUP and some of the similar features of energy efficient applications on the market (some were presented in section 2.3). We could compare the results between the applications, leaving place for improvements and interesting analysis.

Chapter 7

Conclusions

During the past months, we worked on prototyping, iterating and testing an application that can use the power of social networks and ICT to prompt energy savings to households.

In our research, we realized that social intervention have a good result compared or added to other interventions. These interventions have implicit elements, important to push behavior changes, as they create social pressure. Users tend to perform saving actions because they feel that others are observing his behavior.

To change behavior, the users have to recognize that the changes on his household consumption will only be achieved if actions are taken by them. EnergyUP can help users see how effective the actions can be, not only in his household, but in general level or at the households of his friends. On our user tests, EnergyUP has shown good results, and users think this app could help them reduce energy consumption and improve their energy consumption behavior. The evaluation of the application in user tests confirmed the potential for its success.

Nevertheless, pointification technique is another mechanism to achieve user retention, and by keeping the user locked in, we could understand more what works for that specific user. In the end, more suitable saving actions can be provided for that user, pushing savings of energy even further.

The vast number of mobile devices creates the necessary scalability so the application could reach multiple users, enhancing the reach of the application, and the effect EnergyUP can have on energy users. As our features are based on social interventions, the more users we have, better are the results, creating the necessary application of social norms, comparisons and data aggregation that pushes users towards energy saving behavior.

The energy sector is one of the last ones to suffer a big revolution, and due to that this application can be really important. By tackling the waste of

energy present in households, the approach used is technology independent, as it tackles behavior thanks to suggesting correct actions.

Changing the mindset and behavior of the people is the best way to achieve efficient energy use. EnergyUP is a tool with potential to change the environmental perception of each individual, enhancing the savings and reducing the expenses in community level. This is especially important in the times in which we live, when the options to save the resources of the planet are drastically reduced.

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Appendix A

First Prototype

In the first appendix we show pictures of the first prototype, submitted to Aalto ENECOMP 2014-2015. This wireframe version suffered several iterations, and can be checked on next pages.

In this version of the prototype, there were 10 screens, and this version was created with Balsamic¹ tool. This version has “clicking hints”, which allows users to find where the interactive points on the screens, making it easier to understand what is a function and what is a dummy button.

The features present in this prototype includes the Feed, Community list, Challenge screen (completed and ongoing, social and personal challenges), Reports and Tips. The items inside these screens could be accessed, where the user could check the details of items of each list.

¹<http://www.balsamic.com/>



Figure A.1: First Prototype, named EnergyAPP

Appendix B

Discussion about Prototype Iterations

In this appendix we present the differences made on the prototypes since the initial iterations until the definition of the implemented version. We present figures comparing the prototypes created before the third pivot, that generated the Ionic Framework version (see appendix F for the screenshots of this version). In appendix C we show a table with the differences between the functions present in each version.

B.0.0.4 Main Screen

After the conception of the first prototype, we decided to give the application a Home Screen. The Home screen is the screen after the user log in on the system

This screen in first place should contain an energy meter, corresponding to the energy used on the household after fetching data from the smart meter. Also, some elements were added to elicit information to the user once he checks the application.

As it is possible to see in figure B.1, this screen evolved slightly so the system could deliver better information to the user. From the first version until version 3, several elements were added or suffered modifications.

The energy meter representation is one of the elements which suffered modifications, however, nothing major. It was kept in all the versions, but became smaller after the user test. However, from version 2.2 on, a second reference to the consumption was created on the screen, as a bar on the bottom of the screen. This bar is found in other screens, and was based on the idea of giving the user his real time consumption independently of which screen he is on.



Figure B.1: Main Screen evolution of EnergyUP

When it comes to the representation of the challenges, lots of changes took place. After version 1.5, a representation of the challenges completed and ongoing were shown on this screen as well. The evolution of the screen implied a reduction of the size of elements to fit a bigger number icons. The concatenation of the prizes (in this prototype, the pointification system is represented by stars), the separation of number of completed challenges and number of stars earned by the user by completing these challenges were changes made to increase awareness of how he is doing.

Another element which suffered few modification was the field that shows how much monetary savings the user achieved. It was included on version 2.2 and was tested with users.

One of the elements that suffered the biggest changes was the visualization of ongoing actions. On version 1.5, we used a percentage to representing a community goal. We made this information more visual on version 2.0, including an icon with a circular progress bar. In the next version, we represented the ongoing actions as blank star. The representation of incomplete actions was taken out of the screen in version 2.3, and came back on version 3.0. In this version, a suggestion of the next challenge to the user was represented in the middle of the screen. An icon representing that the challenge was individual, how many stars the user would get if he perform this challenge, as well as the difficulty and duration of the challenge along with his title.

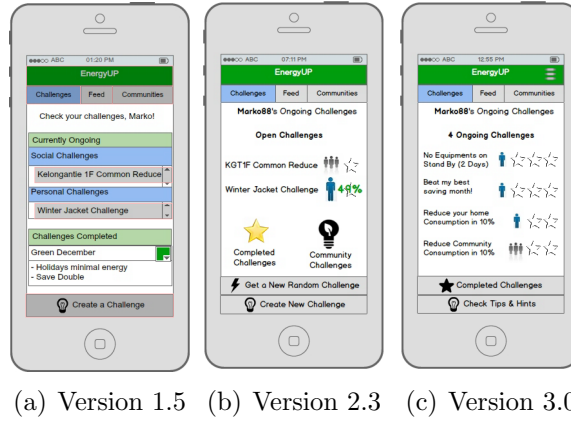


Figure B.2: Challenge Screen evolution of EnergyUP

B.0.0.5 Challenges and Actions Screen

The challenge screen also suffered changes during the evolution of tests of the prototype. In this subsection, we describe which changes were made on the screen which contains the actions proposed for the user, as well as the way we display the actions itself. Following, we present the changes on challenge screen, and they can be checked on figure B.2.

Before version 1.5, we separated on the screen 2 important items: the past challenges of the user, and the current ones. On the ongoing challenges, we separated the social and personal challenges, so the user could notice there should be common challenges on the application. This screen can be seen in figure A.1, item (a), on the appendix A.

In version 1.5, we kept the same elements from previous version. However, we emphasized the personal challenges, creating an option to allow the user to click on it, checking its description. This could help the users to differentiate the types of actions proposed on the application, giving more clarity to the purpose of the challenges. Also we renamed the tab of challenges the user already did, from “Past Challenges” to “Challenges Completed”, due to the same reason. On the bottom of the screen, we displayed a button so the user could create a new challenge to his list.

We changed the presentation of the elements on version 2.0 of the prototype. We decided to create less sentences, and create more icons on the screen. First, we changed the name of the screen from “Currently Ongoing” to “Ongoing Challenges”, as the previous name is redundant.

The actions proposed by the user now were displayed as the name of the challenge, an icon representing the characteristics of the challenge (i.e. social

or personal, according to the number of persons on the icon) and a circular progress bar to inform the user the percentage of completion of his challenge.

The completed challenges became a new screen accessed by an arrow button. Also, we created the concept of Achievements, which should be represented by big goals the user completed (i.e. a set of challenges from the same type, an aggregation of savings being represented in an interesting way, etc.), linked by another arrow button on the same screen. In this version, we kept the button that allows the user to create new challenges, and added another button of the same kind to get a random challenge to the user list, to see if users would like this type of proposal.

Few changes were made for the prototype version 2.2, where the differences lay on the cleanness of the screen and better representation of objects. Three changes were made in this version. First, the name of the screen changed to “Open Challenges”. Second, the progress bar was replaced by a percentage number representing the completion of the challenge, and a blank star was also placed on the place of the circular icon to illustrate the incomplete action. The last change was made to give more pattern to this screen. We took the arrow buttons out, replacing them by icons to redirect the user to the Completed Challenges screen (a star) and to the Achievements Screen (an eco-bulb). In this version, the Achievement screen was named “Community Challenges”.

For version 2.3, we decided to represent how many stars the user could get by completing a given action. The screen changed the name again to “Ongoing Challenges”, and the number of ongoing challenges on this screen was placed before the title. We kept just two buttons on this screen, one redirecting to the “Completed Challenges”, and another one to allow the user to “Work on Next Challenge”. This button was created to give push the user to work on the challenge that suits the most on that moment, related to the easiest challenge on the list or one closer to be completed.

The changes promoted for version 2.3 were maintained on version 3.0. The only small changes were regarding typos and the replacement of button “Work on Next Challenge” for “Check Tips and Hints”, to place this screen in an easy-to-find place.

B.0.0.6 Challenge Details

Following, we depict the details of a given challenge selected by the users and the iterations they suffered.

On version 1.5 of the prototype, we represented the challenge details only with text, informing the users about what that given challenge represents. On version 2.0 and 2.2, we made two little modifications. We first added an icon

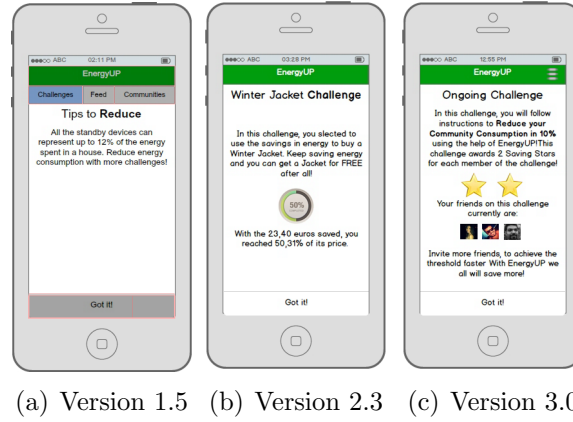


Figure B.3: Details of a Challenge evolving of EnergyUP

to the center of the screen, a circular progress bar seeing on previous screen representing percent of completion of that challenge. Also, we informed the user about how much money he saved so he could redirect this budget to buy a tangible thing. This was planned to be tested, having an interesting acceptance from the users (see subsection 5.3.1, further).

Versions 2.3 and 3.0 had the same representation of this screen. We replaced the progress bar for the amount of points (in this case, stars) the user would get for completing this challenge, and the friends of the user on this current challenges.

B.0.0.7 Community Screen

In the first versions of EnergyUP, the community (or common) challenges were inserted on the challenge screen. Further on, we changed the community challenges to the Challenge Screen, but kept the details of the community to inform the user. Following, we discuss the changes made on this screen, and also the modifications on the details of the communities.

Version 1.5 and 2.0 are similar, containing the current communities of the user, a text button to create a new community, and a search bar to find more communities. The communities can be clicked, so the user could check its specific details, as shown further, on section B.0.0.8.

For version 2.2, we included icons to represent what type of community was each one of the list. According to the user tests, those icons were not too intuitive, therefore we added a help button (represented by a question mark inside a circle) to provide this information to the users. Also, we included two buttons on the screen: one representing the content of the previous text



Figure B.4: Community Screen evolution of EnergyUP

button, so the user could create a new community, and another one so the user could calibrate the household smart meter with the application.

In version 3.0, we took the home calibration button out, placing differently. The mentioned changes can be checked on the figure B.4.

B.0.0.8 Community Details

Once an item of the community list was clicked in versions 1.5, 2.0 and 2.2, the user could check the details related to that community, and a list of the months and information about the performance of the community on EnergyUP during that period. The details mentioned in this subsection can be found in figure B.5.

In version 2.0, the button of home calibration was added on this screen. As previously mentioned, this button changed places, and left this screen from version 2.2 on. Also, from the version 2.2 on, colors the efficiency of the community on a particular item was represented by colors.

From version 2.2 on, the energy meter bar present on the main screen was also show in this place, in order to give the user information about the energy measurement on this community.

Versions 2.3 and 3.0 have the same features and did not suffer modifications. From version 2.3 on, we included a button which would allow the users to invite friends to that community. Also, an icon showing what type of community was added to the name of the community. We created a representation of how many users were in that community, and how many of those are actual friends of the user, representing them with pictures, to connect the user not only with the feeling of community, but to create the representation

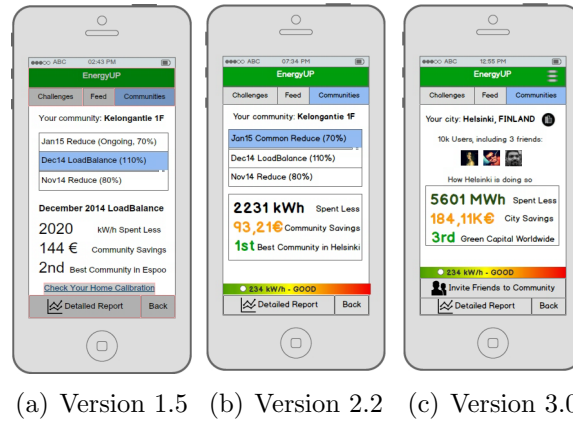


Figure B.5: Evolution of Community Details of EnergyUP

of modelling and show the strong ties of the user to create engagement.

Appendix C

Table with Prototype Comparison

Following, we present the content described in appendix C, in form of a table, containing the main iterations on the most important functions of EnergyUP, showing the evolution between the prototype versions.

In this table, among other things, it is possible to see that:

- Feed, Community list, Community Description, Challenge Description, Create a Challenge (in newer versions, add an Action), Report, Tips Screen (was merged with Challenge List on newer versions) were present in most of the versions. Also, the Challenge List was practically in all versions (where ongoing and completed challenges were in the same screen, and separated on prototype version 2.0 on).
- Pointification (i.e. representation of points rewarded for the user in exchange of the completed actions) was added to version 2.0 and suffered modifications (e.g. the saving stars were replaced by green leaves) from the JavaScript version on.

Following, we present a table containing the functions and screens created, and the versions created, since the first one (see appendix A for screenshots, and section 5.2.1 for details) until the last version, implemented with Ionic Framework (screenshots can be found in F, and discussion about its conception, in section 5.4). The features presented in each prototype are completed with an 'X'.

Function x Prototype Version	V1.0	V1.5	V2.0	V2.2	V2.3	V3.0	JS	Ionic
Logo Screen		X	X	X	X	X	X	X
Moto				X	X	X	X	X
Service Agreements			X	X	X			
Log-in			X	X	X	X		
Home		X	X	X	X	X		
Color Gradient				X	X	X		
Gradient Info (pop-up)				X	X	X		
Feed (Chat)	X	X	X	X	X	X	X	
Feed Item	X	X	X	X	X	X		
Community List	X	X	X	X	X	X		X
Create Community		X	X	X	X	X		
Types of Community (pop-up)					X	X		
Community Description	X	X	X	X	X	X		X
Community Created (pop-up)		X	X	X	X	X		
House Calibration		X	X	X	X	X		
Calibration Saved (pop-up)		X	X	X	X	X		
(Mixed) Challenge Screen	X	X						
(Ongoing) Challenge List			X	X	X	X	X	
Challenge (Action) Description	X	X	X	X	X	X	X	X
(Completed) Challenge List			X	X	X	X		X
Create Challenge (Add Action)		X	X	X	X	X	X	
Complete a Challenge/Action		X						X
Abandon a Challenge/Action								X
Suggested Challenge/Action								X
Pointification (Stars or Leafs)			X	X	X	X	X	X
Challenge Type Setup		X	X	X			X	
Community Shared Challenge	X						X	X
Top Challenges/Actions							X	X
Ranking(Achievement) Screen	X	X	X	X	X	X		
Description of Achievement		X	X	X		X		
Profile					X	X		
Report (Consumption Graphics)	X	X	X	X	X	X	X	
Energy Consumption		X	X	X	X	X		
Budget Savings		X	X	X	X	X		
Consumption Analysis		X	X	X	X	X		
Tips Screen	X	X	X	X	X	X		
Example of Tip (pop-up)		X	X	X	X	X		
Create a Tip	X	X	X	X	X	X		
Top Menu				X	X	X		
Exit Screen				X	X	X		

Table C.1: Table containing the screens and functionalities present on the prototypes

Appendix D

Table of First User Test

In the appendix D, we present a table of the answers from the first user test we made.

Section 5.3.1 talks about the general result of this user test, where we aggregated the information provided by the users in order to create and change user functions, to define assumptions, and correct issues we did not foresee.

The questions made to users were mostly open questions, related to their experience with the prototypes provided, and their perception of the purpose of the application. The questions were made so the answer were qualitative, with no wrong answer. We tested our prototype with 8 subjects, homogeneous in knowledge. The tests took around 15 to 20 minutes each.

More details about the first user test can be found in section 5.3, in chapter 5.

Subject / Question	User1, Female	User2, Male	User3, Male	User4, Male	User5, Male	User6, Female	User7, Male	User8, Male
Understand the purpose	Thinks So	Thinks so	Yes	Yes	Thinks So	Yes	Yes	Yes
Seen Similar Apps	No	No	No	No	Waze (Ranking / Position System with Scoreboard)	No	No	Clash of Clans (Achievement System)
Feature Issues	Icons Not clear	Icons not clear	Names not clear	Names not clear	Missing add new challenges	Lot of dummy buttons	Lot of information on pop-ups	Achievements are confusing
What more should be built	Weather data Prediction / Notification of new efficient appliances on market	Nothing	Show user ranking or badges to show if he is experienced	Share report with neighbor	Energy threshold alarm	Reports with peaks of neighbors	Set a threshold to himself	Shortcut menu on the top
Data Sharing	Maybe	Only aggregated data	Only to close friends, or aggregated data	Only the Energy Consumption	Yes	Yes	Only energy consumption	Yes
Comments	Did not understand where the data came from	Fear that the app will tell him what to do without understanding him	Suggested not to separate personal and community challenges on a screen	Create communities of football teams	Liked the money saving feature	Liked the forum and budget screen	Liked to create a challenge	Suggested insertion of how many people live in the household
Would you Use it	Yes	Yes, but with better usability	No		Yes	Yes	Yes	Yes
Share on Facebook	Yes	No	Do not have Facebook	Do not have Facebook	No	Yes	No	Yes
3 most Re-membered Functions	Gamification, Fun Sentences, Winter Jacket Challenge	Ratings, Data Share, Winter Jacket Challenge		Small tasks, Sharing information, Efficiency in consumption	Get consumption data automatically, Create a challenge, Daily Report	Communities, Setting and completing challenges, Knowing neighbors consumption	Create a Challenge, Sharing information with friends, Comparison between communities	Challenges, Award System, Create Personal information
Problems with Navigation	Yes, used back buttons, but got lost some times	No, got lost some times	No, got lost in community challenges	No, got lost few times	Yes, was very careful and used back buttons to confirm his position	-Tried to log in with Facebook - No, Had issues with the flow	Yes, went very straight forward	Stopped often to go back and check where he was

Table D.1: Table containing the results of the first user test

Appendix E

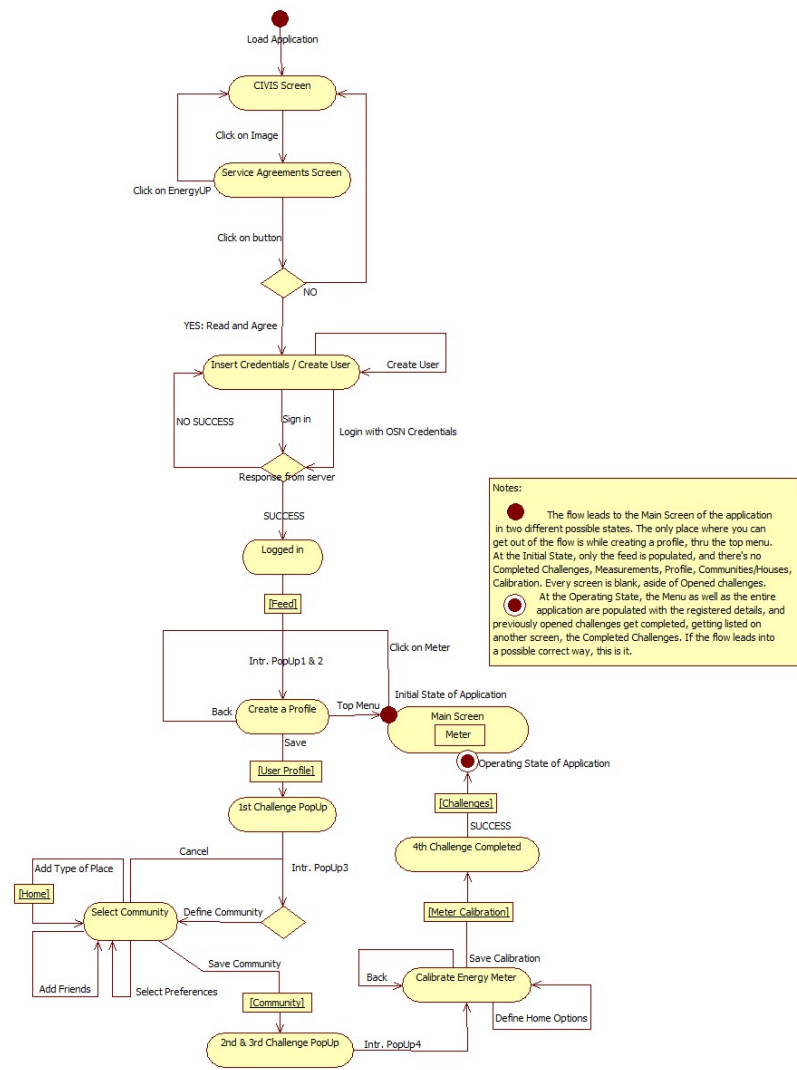
Flow Diagram of the Prototype

In this appendix, we show the flow we expected the users to follow on the first user test, discussed in section 5.3, using an activity diagram.

It is possible to see in this picture, representing a simplified version of the balsamic prototype, that the users should follow a sequence related to the customization of the application according to their needs.

This means that, after the login screen, we expected that the user could have a direct flow, creating an user profile, creating/selecting a community to be part of, and then setting up his household environment (e.g. defining how many rooms he has in his place, the type of electric appliances, connecting to the smart meter, etc.), so he can start using the application.

This diagram also shows that, in this version, the user was conducted to perform these actions by pop-up screens, which informed the users what was the next challenge to be complete. Therefore, the first challenges/actions to be performed by the user were not directly related to energy saving, but were a tutorial of how to configure the application.



(a) Activity Flow Diagram

Figure E.1: Activity Diagram showing the flow of user test

Appendix F

JavaScript Implemented Version

In this appendix, we present screenshots of EnergyUP implemented with Ionic framework.

As described in section 5.4.1, this version was created after the third pivot, in order to make EnergyUP more user driven, with less features that may confuse the users in first place.

We used this version on the second user test, focused in attesting the usefulness and ease of use of EnergyUP. detailed in section 5.5.

The screens presented following show the introduction screen, with login scheme, leading to a tab containing the Action list of the user. This screen replaced the old ongoing challenge screen. The other tabs of the application are the Household and the User Communities.

Also, it is possible to see actions, such as active tasks (tasks on you list that you did not complete yet, but you also did not started working on it), suggested or pending actions (former ongoing action). This version also allows users to give feedback after starting or canceling an action.

The link to this prototype is open to public, and (currently) can be accessed by the following URL: <https://fruitiex.org/civis/#/welcome>.

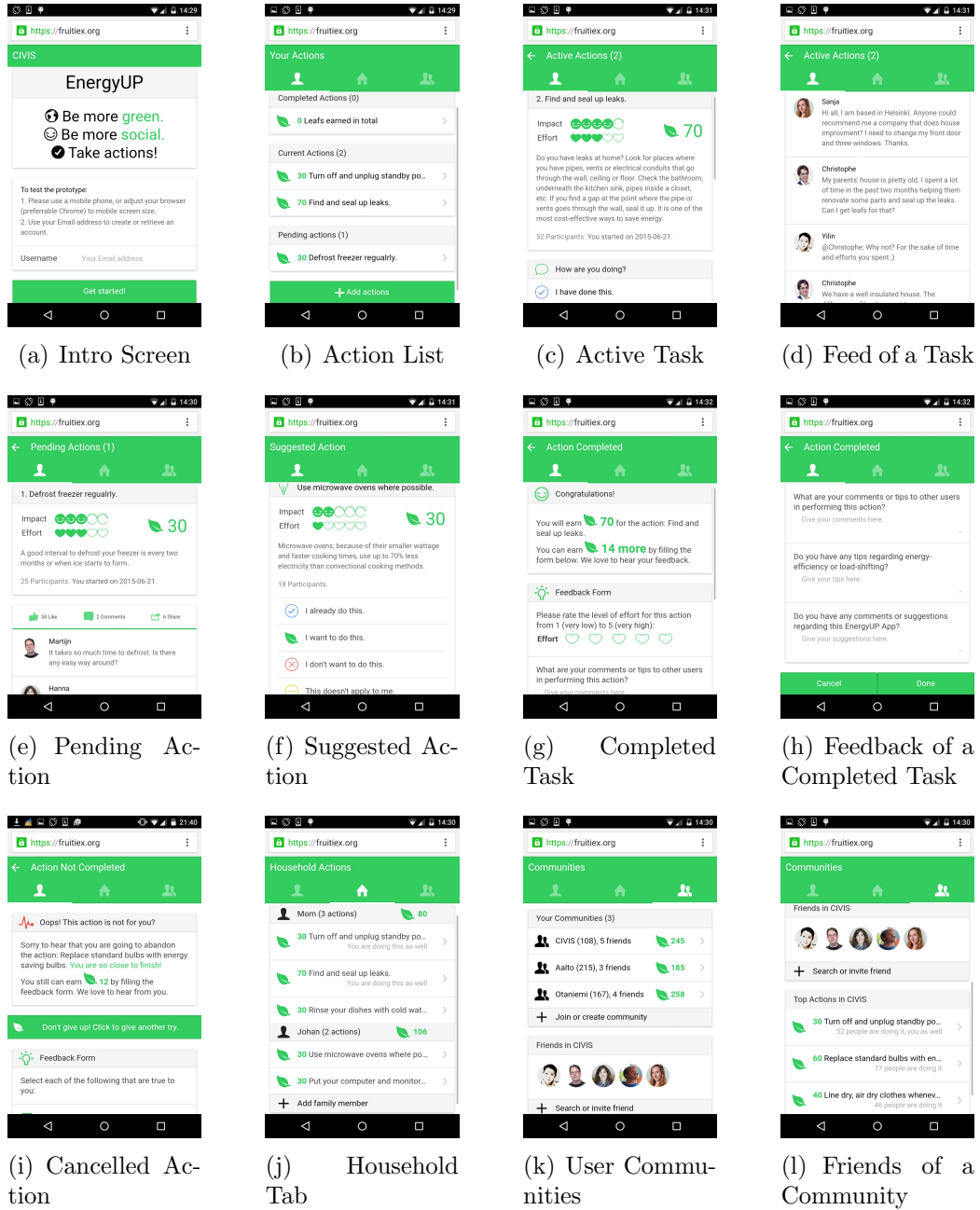


Figure F.1: Clickable full-working version, implemented in JavaScript

Appendix G

Graphics of Second User Test

In this appendix, we present the graphic results of our second user test, providing the aggregation of the data from our test subjects. The graphics were made with Google Forms¹, where we inserted the answers collected on our second user test.

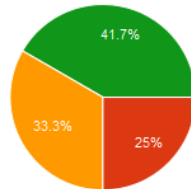
The Second User test was conducted during the Open Source Circular Economy Days (OSCE 2015) Helsinki, where EnergyUP had a test site. We used Samsung Galaxy S3 and S4 phones to test 24 pro-green users.

In section 5.5, we presented the details of the test, including the Technology Acceptance Model and questions to attest the Perceived Usefulness and the Perceived Ease of Use of the application.

We discuss the details found in the following graphics in subsection 5.5.2, giving emphasis on the TAM variables.

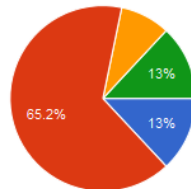
¹<https://www.google.com/forms/about/>

How often do you try to conserve energy?



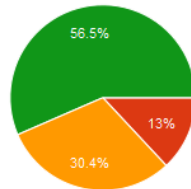
1 - Never	0	0%
2 - Sometimes	6	25%
3 - Frequently	8	33.3%
4 - Almost Always	10	41.7%

In deciding to conserve energy, how important is it to you ... that using less energy saves money?



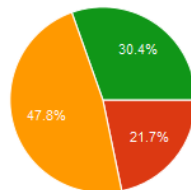
1 - Not at all important	3	13%
2 - Somewhat important	15	65.2%
3 - Very important	2	8.7%
4 - Extremely important	3	13%

In deciding to conserve energy, how important is it to you ... that it protects the environment?



1 - Not at all important	0	0%
2 - Somewhat important	3	13%
3 - Very important	7	30.4%
4 - Extremely important	13	56.5%

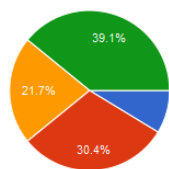
In deciding to conserve energy, how important is it to you ... that it benefits society?



1 - Not at all important	0	0%
2 - Somewhat important	5	21.7%
3 - Very important	11	47.8%
4 - Extremely important	7	30.4%

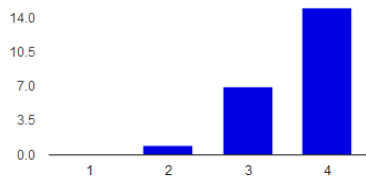
Figure G.1: Results from the Second User Test, part 1

In deciding to conserve energy, how important is it to you ... that a lot of other people are trying to conserve energy?



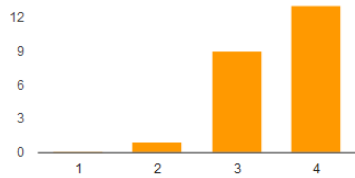
1 - Not at all important	2	8.7%
2 - Somewhat important	7	30.4%
3 - Very important	5	21.7%
4 - Extremely important	9	39.1%

How much do you think ... conserving energy will benefit society?



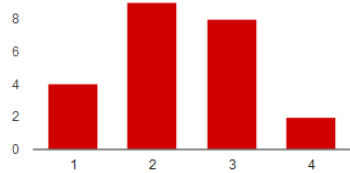
Not at all: 1	0	0%
2	1	4.3%
3	7	30.4%
Extremely: 4	15	65.2%

How much do you think ... conserving energy will protect the natural environment?



Not at all: 1	0	0%
2	1	4.3%
3	9	39.1%
Extremely: 4	13	56.5%

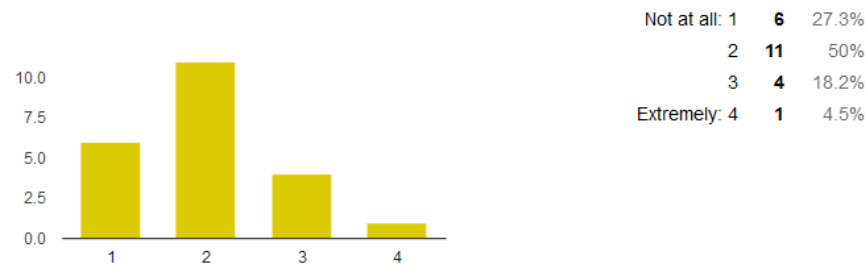
How much money do you think ... you can save by conserving energy in your home?



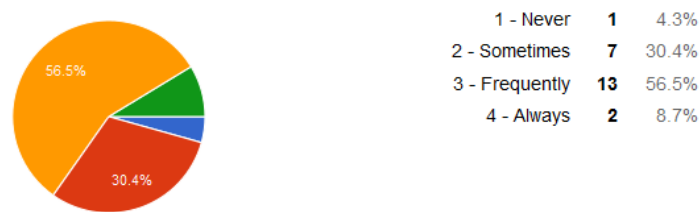
Not at all: 1	4	17.4%
2	9	39.1%
3	8	34.8%
Extremely: 4	2	8.7%

Figure G.2: Results from the Second User Test, part 2

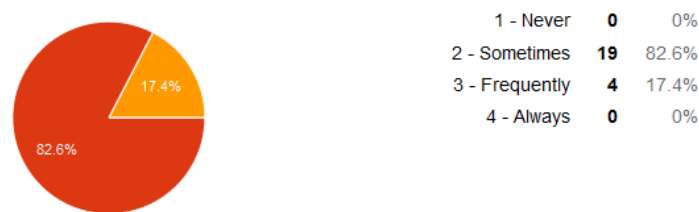
How often do you think ... your neighbours try to conserve energy?



How often do you think ... your family members try to conserve energy?



How often do you think ... residents of your city try to conserve energy?



How often do you think ... Finns try to conserve energy?

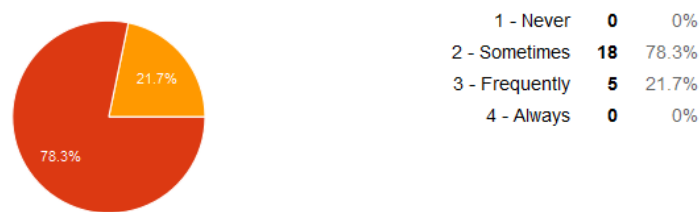
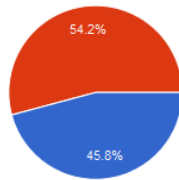


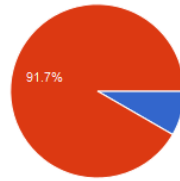
Figure G.3: Results from the Second User Test, part 3

Tell us about you: What is your gender?



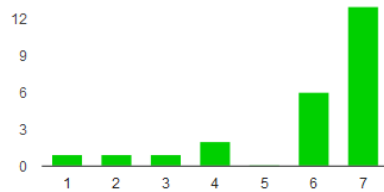
1 - Female	11	45.8%
2 - Male	13	54.2%
Other	0	0%

Which is your dominant hand?



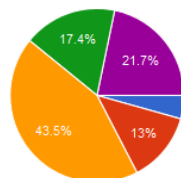
Left	2	8.3%
Right	22	91.7%

Tell us about you: How familiar are you with using a touchscreen?



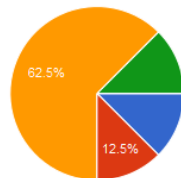
A little familiar: 1	1	4.2%
2	1	4.2%
3	1	4.2%
4	2	8.3%
5	0	0%
6	6	25%
Totally familiar: 7	13	54.2%

Tell us about you: What is the size (approx.) of the home you live in?



1 - less than 20 m2	1	4.3%
2 - 20 to 30 m2	3	13%
3 - 30 - 50 m2	10	43.5%
4 - 50 - 70 m2	4	17.4%
5 - more than 70 m2	5	21.7%

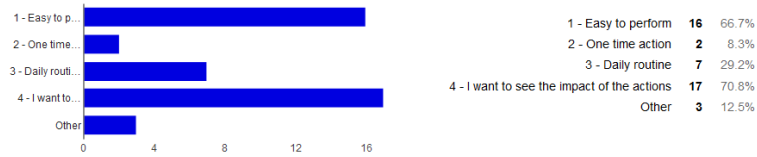
Tell us about you: How would you describe the home you live in?



1 - Detached house	3	12.5%
2 - Terrace house (rivitalo - Finnish or townhouse - U.S.)	3	12.5%
3 - Apartment in a residential building	15	62.5%
4 - Student apartment	3	12.5%
Other	0	0%

Figure G.4: Results from the Second User Test, part 4

What would be important for you with regard to the actions?



Who would you be willing to share your actions with?

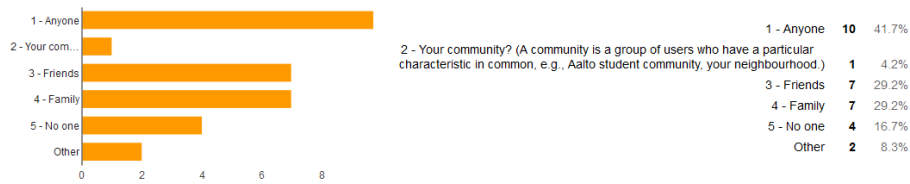
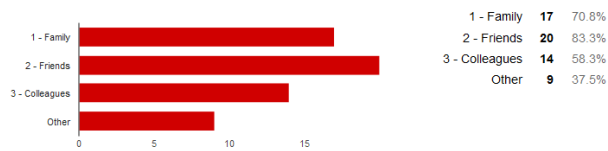
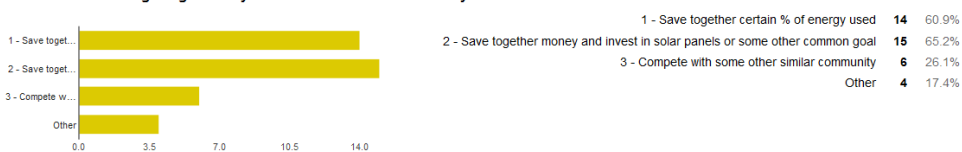


Figure G.5: Results from the Second User Test, Test Scenario I

What kind of communities you would want to create/join?



What kind of challenges / goals do you want to have as a community?



Would you be interested in these types of feedback:



Figure G.6: Results from the Second User Test, Test Scenario III

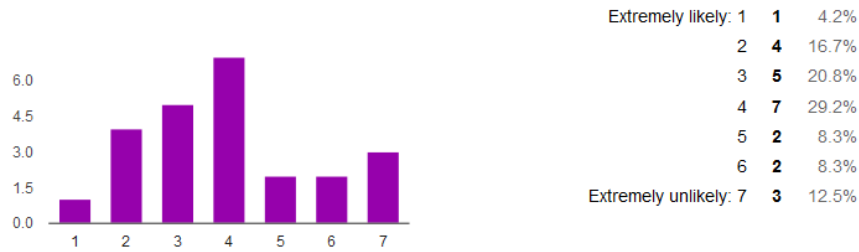
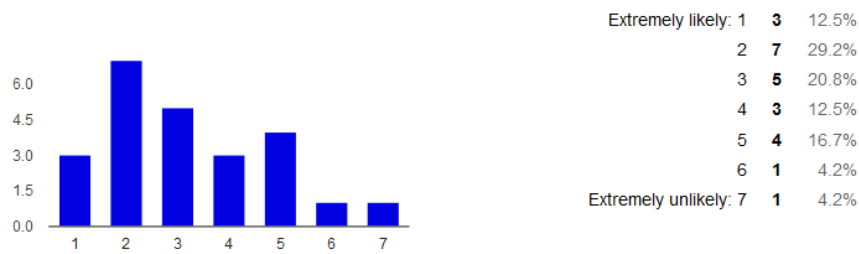
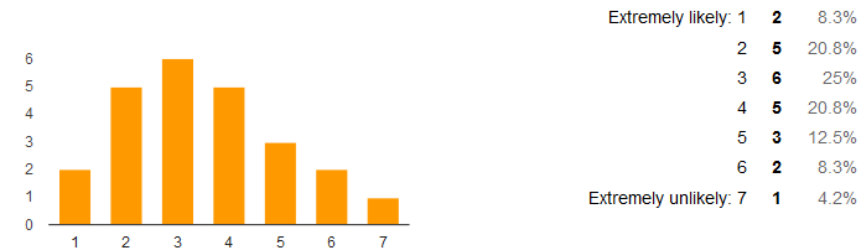
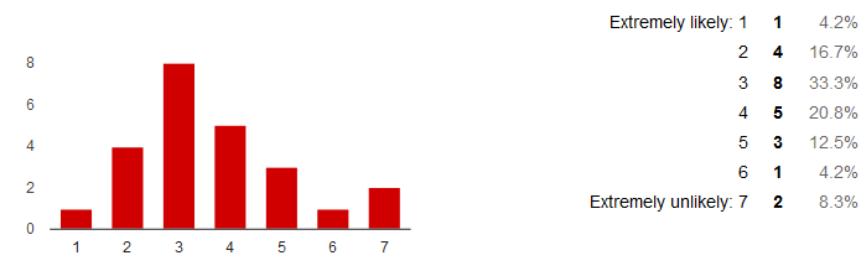
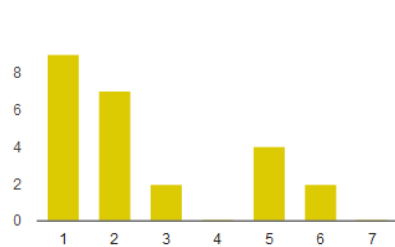
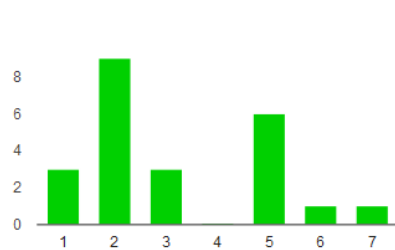
Using the EnergyUP app would enhance my effectiveness on reducing energy use**I would find the EnergyUP app to be useful in reducing energy use****Using the EnergyUP app would make it easier to reduce energy use****Using the EnergyUP app would improve my performance in reducing energy use**

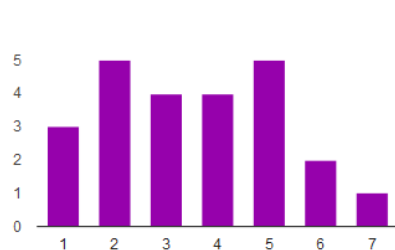
Figure G.7: Results from the Second User Test, Perceived Usefulness

Learning to use the EnergyUP app would be easy for me

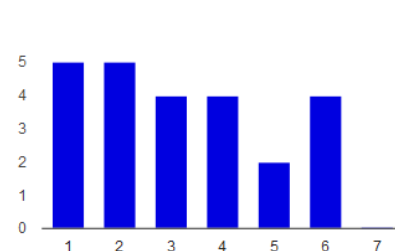
Extremely likely: 1	9	37.5%
2	7	29.2%
3	2	8.3%
4	0	0%
5	4	16.7%
6	2	8.3%
Extremely unlikely: 7	0	0%

My interaction with the EnergyUP app would be clear and understandable

Extremely likely: 1	3	13%
2	9	39.1%
3	3	13%
4	0	0%
5	6	26.1%
6	1	4.3%
Extremely unlikely: 7	1	4.3%

I would find the EnergyUP app to be flexible to interact with

Extremely likely: 1	3	12.5%
2	5	20.8%
3	4	16.7%
4	4	16.7%
5	5	20.8%
6	2	8.3%
Extremely unlikely: 7	1	4.2%

I would find the EnergyUP app easy to use

Extremely likely: 1	5	20.8%
2	5	20.8%
3	4	16.7%
4	4	16.7%
5	2	8.3%
6	4	16.7%
Extremely unlikely: 7	0	0%

Figure G.8: Results from the Second User Test, Perceived Ease of Use